National Society for Clean Air

43rd Clean Air Conference Edinburgh

11-15 October 1976

Part 1
Pre-prints of papers

nsca
136 North Street
Brighton BN1 1RG
England

43rd Clean Air Conference
Edinburgh 11th - 15th October, 1976

NOISE AS AN AIR POLLUTANT

Dr. A.J. Crosbie
University of Edinburgh

THE INDUSTRIAL AND LOCAL AUTHORITY APPROACH TO NEIGHBOURHOOD NOISE

J.H. Richardson and R.W. Smith
Acoustic Technology Ltd.

SMOKE CONTROL - A REVIEW OF THE PRESENT POSITION AND THE WAY AHEAD

W.J.S. Batho
Department of the Environment

SMOKE CONTROL IN AN INDUSTRIAL AREA; EXPERIENCE IN NORTH EAST ENGLAND

L. Mair
Newcastle upon Tyne

THE FINDINGS AND RECOMMENDATIONS OF THE ROYAL COMMISSION ON ENVIRONMENTAL POLLUTION

Sir Brian Flowers
Imperial College of Science and Technology

PEOPLE, POLLUTION AND RETRIBUTION

Professor G.M. Howe
University of Strathclyde

RURAL POLLUTION - THE HIGH PEAK, DERBYSHIRE
(with particular reference to stone quarrying)

I. Holmes
Borough of High Peak

ENERGY SOURCES - WHAT ARE THE ALTERNATIVES

Dr. J.C. McVeigh
Brighton Polytechnic

THE SCOPE FOR SOLAR ENERGY IN THE ENERGY PATTERN OF THE FUTURE

P. Brunt
G.T. Systems Ltd.

THE UTILISATION OF SOLAR ENERGY

B. McNelis
Solar Energy Developments

THE DISPOSAL OF TOXIC AND RADIO-ACTIVE WASTES

Dr. D.H. Sharp
The Society of Chemical Industry

The Coat of Arms depicted on the front cover is of The City of Edinburgh District Council

43rd ANNUAL CONFERENCE

EDINBURGH

11th - 15th October, 1976

NOISE AS AN AIR POLLUTANT

by

Dr. A.J. Crosbie
Department of Geography
University of Edinburgh

National Society for Clean Air,
136 North Street,
Brighton BN1 1RG.

Noise is part of the climatic environment. Atmospheric characteristics act as stimuli on all the human senses and noise and smell play important roles in an individual's perception of the environment both in terms of its congeniality and its hazards. This interpretive role of noise has increased as a result of the modification of climate in urban areas where not only has the physical nature of the site been changed and the atmospheric composition altered, but there has been an ever increasing release of energy as sound. Air is an excellent medium for the treatment of this energy and it is in this sense that noise is an air pollutant as opposed to the narrower definition of pollution as a contaminant of the atmosphere.

Concern for noise is not new. The same factors which led to chemical atmospheric pollution, i.e. urbanisation, industrialisation, increasing population, technological changes and a rising standard of living, have also resulted in the generation of more noise. Accordingly, there are many similarities between the two forms of pollution. Both are described as deplorable in eighteenth century literature while in the succeeding century physicians were alarmed just as much by noise in the new factories and towns as they were by odours and smoke. The Noise Abatement Society was formed in 1959 and the Committee on the Problem of Noise (the Wilson Committee) issued a final report in 1963 and highlighted the basic question in consideration of the problem, viz. what is noise?

To the physicist noise is composed of sound with a continuous spectrum of frequencies while to the electronic engineer noise is an undesired sound or disturbance; to the lawyer, it is an excessive, offensive, persistent or startling sound; to the Wilson Committee it was "sound unwanted by the recipient". While there is no difficulty in establishing the level at which noise causes irreparable damage to hearing, or in recognising that complete silence is psychologically disturbing, there is no bench mark for the noise level of ambient air. At the same time, individual responses and preferences extend over a very wide range. Further consideration therefore requires an understanding of the physical complexities of noise and an attempt to evaluate subjective reactions.

The Measurement of Noise

Just as smoke is not a distinct chemical species, so noise is a variable collection of sound energy waves. Any individual sound will have a measurable frequency (in cycles per second (cps) or in hertz Hz), pressure (in bels) and intensity (in watts)), but noise usually comprises an aggregate of sounds which may, or may not, be individually measurable. Noise recording involves the use of two instruments, a sound level meter and an analyser which separates noise into tonal components. Unlike chemical pollutants where minute or trace quantities are significant, the magnitudes in sound measurement are large. For this reason a logarithmic scale - the decibel scale - is adopted but it makes comprehension and comparison of data difficult. Further, the results may be weighted to take account of the loudness of the weaker sounds to human beings. Again, unlike chemical pollutants, there has yet to be devised a simple, foolproof and economic recorder which would permit an overall monitoring system similar to the National Survey of Air Pollution. The data available, therefore, are usually for discrete situations and specific locations and have limited value either in formulating general practice or in predicting trends.

The quantitative measures of sound, however imperfect, are merely one factor in classifying noise. Temporal variations are also important. On the one hand the characteristics of the noise source whether continuous, in which case the frequency will be important, or intermittent, in which case the repetition rate, possibly irregular, will be significant, will provoke varied reactions. In the latter category impulse noise e.g. from pneumatic drills, deserves special attention because not only is it difficult to measure and evaluate, which may

perhaps explain the paucity of guideline standards and legislation, but it is usually accepted as a more serious environmental hazard than higher but steadier noise levels. On the other hand, the weekly and daily cycle of economic and social activity affects the threshold level of noise acceptance which is at a minimum during the night. Meteorological conditions also influence the transmission of noise. Wind, atmospheric density and the presence of inversions can either inhibit or enhance the transmissibility of the air.

Sound waves are dissipated in a strict mathematical relationship with distance although with concentrations of multiple sources and the configuration and complexities of urban situations this is not straightforward. In consequence, it is difficult to establish gradients or, in applied terms, to draw traffic noise contours for planning purposes. The most obvious application of the physical law is in the initial rate of climb of jet aircraft whereby the source of the noise is removed to an acceptable vertical distance as soon as possible. The construction of barriers will also impede sound waves although to be effective they must be situated either close to the source or to the listener. The fundamental point to note is that noise is a local problem, albeit frequent and widespread in its occurrence,and that, unlike contaminants there are no global or cumulative features.

In defining threshold levels of noise the criteria can only be derived from an examination of human responses to such variables as durations at particular levels, the composition of the noise, the sequence or frequency, and so on. Several indices have been devised for particular situations. The Wilson Committee in considering aircraft noise introduced the Noise and Number Index (NNI). This is an equation based on the perceived noise in decibels (PndB) in which the sound pressure level (SPL) is measured in frequency bands, each an octave wide, for each individual aircraft, combined with the frequency of flights. Another index is L_{10} designed to indicate traffic noise on a 90 per centile basis from 6 a.m. to midnight, while another example is LEQ in which annoyance is quantified on the basis of decibel measures (Tillotson, 1976). All of the indices so far devised are subject to criticism, largely on the qualitative yardsticks used in evaluating human response. Recently, an attempt has been made to use economic criteria for this purpose (Walters, 1976) with particular reference to property values in the vicinity of airports. The problems involved in constructing noise indices based on subjective assessment are compounded when standards are proposed. (Waller 1974). These can at best be indicative, at worst be misleading.

The Effects of Noise

The major categories affected by noise are buildings and people. The effects of noise on, and within, buildings have received considerable attention particularly by the Building Research Station. Superficial or structural damage from shock waves or, more commonly, vibration are specialised fields of research. External noise forms part of the vibrational environment in which heavy commercial vehicles and supersonic jet aircraft contribute in different ways. Insulation and the development of absorbent materials help to reduce sound propagation, but the older parts of many cities, such as Edinburgh, are ill prepared for heavy traffic. Internal noise in also increasing and, somewhat paradoxically, in a growing number of buildings, there is the use of background noise to dampen sound exchange.

People may suffer from noise in three ways: physiologically, psychologically or simply by annoyance. Prolonged exposure to noise in the 80-90dB range will cause loss of hearing either temporary or permanent, while levels exceeding 90 dB are usually synonomous with reduced efficiency. Noise induced is an occupational hazard in a number of industrial processes such as metal mills, engineering, textile works, and glassworks, but such situations are subject

to control and regulation. These apart, there are little apparent direct physical effects. In some instances if there is continuous interference with sleep deleterious effects on health are to be expected and have been observed. The continuous adaptation of human beings to a changing environment, however, can lead to considerable adjustment. This is recognised, for example, in the acceptable night time noise levels which increase for locations ranging from rural areas to centre city.

There is little hard evidence on which to draw conclusions about the psychological and annoyance effects. In large measure, this is due to what biologists term the host factor, i.e. the different response in each individual. The acceptable level of noise will depend on age group, sex, occupation, socio-economic class, cultural group, and, for a given individual, on the particular activity in which he is engaged. The sensitivity of the human ear also varies widely with frequency. Presbycusis or diminished hearing with age literally means that the old cannot hear what the young enjoy; by the same token impaired hearing may lead to a desire for increased volume as a counteraction by the individual. Aesthetic factors further bedevil attempts to generalise on the definition of noise as 'sound unwanted by the recipient'. Not everyone might agree with E.M. Forster that Beethoven's Fifth Symphony is the most sublime noise ever to entrance human ears but equally many would argue the aesthetic merits of 'pop'. Surveys on the response to noise by different nationalities can give rise to diametrically opposing results, for example those between Sweden and Italy.

The psychological effects of environmental noise remain not proven although the use of white noise i.e. undifferentiated noise has been deplored in psychological warfare. Stress is an important factor in human well-being but one which is difficult to analyse. The effect of environmental noise, moreover, may be subsumed in a greater pattern. In an urban environment the adaptation required to compensate for distracting stimuli is compounded by the physical adjustments which are also involved. Climatic parameters, noise and population density are only three of many interacting forces operating in an urban situation. For example, the effects of urban air pollution on human health has been extensively studied but the link remains far from clear. What is recognised is that air pollution is part of an urban factor in which noise is also a contributing factor.

Annoyance from noise, either by interfering with speech communication or by intruding into one's consciousness, would appear an obvious effect. But noise, as a nuisance, is really a question of degree. It depends on the pitch, irregularity, rhythm, unexpectedness and meaning of a specific noise. Loudness, by itself, need not be critical. The attitude of the individual may also lead to considerable incompatability between the physical and psychological thresholds of tolerance. It must be acknowledged that, in some cases, anti-noise pressure groups simply reflect self interest and there is occasionally a somewhat arrogant dismissal of the vast majority of the population who do not complain about noise as 'imperturbables'. The fact is that environmental noise is usually at a maximum in heavily industrialised, densely populated areas with high vehicle traffic where the income group and the number of complaints about noise are both low. Such differing responses are significant in calculating the costs of proposed remedies.

Again, the localised nature of noise sources is a key factor in evaluating the effects. Indoor and outdoor sources, from babies' crying to motor cycles, will provoke a different set of responses at differing times. Much depends on the distance from, and the direction of, the source together with recognition of its identity. The perception of noise in the environment of the individual illustrates the third major fact in noise pollution, that is, it is largely a subjective problem. Three categories deserve further consideration however

because of their more widespread impact.

Road Traffic

Road traffic is probably the source of the most pervasive noise. The composition of this noise includes engine noise, tyre noise - particularly noticeable with radial tyres on cobblestones - body noise and vibration. The level of noise depends on a number of factors such as the volume of traffic, the percentage of commercial vehicles since diesel engines generate the most noise, the gradient of the road, the traffic flow characteristics, and the road surface. Spatial variations are therefore marked and are influenced by the complexities of the particular urban situation, the linkages between one area of town or city and another, and the proximity of the listener often expressed in terms of distance from the kerbstone. Temporal variations are usually related to the economic and social characteristics of the particular neighbourhood. There is in some cases a simple physical restriction on the number of vehicles which may pass through the narrower streets of the older towns. This places an upper limit on the air pollution which is emitted but it can also lead to high noise levels and, as already noted, structural damage from vibration.

The role of heavy commercial vehicles as a contributor to road traffic noise is widely recognised. In consequence, more attention is given to the surveillance, control and measurement of noise from this source than from any other road user. At present the acceptable maximum noise level from such vehicles is 90 dB but the proposed standards for the European Economic Community is 80 dB. While modifications to engine noise are possible, it is more difficult to reduce the other sources of noise e.g. tyre noise from such vehicles.

Road traffic highlights some of the problems in noise control. Firstly, there is the problem of multiple sources. Each specific source makes its own contribution, some great, some small, depending on a variety of circumstances. The measurement of noise from mixed sources is difficult and monitoring and control of any individual source is, by and large, impractical. In any pollution problem the first essential is to reduce the number of sources. Secondly, remedial measures can reduce noise levels significantly. Barriers, cuttings and location away from areas of high population density are common practice in designing and constructing new roads and by-passes. The problem is economic. Thirdly, planning for the future also has economic constrainst but there are locational issues of equal or greater importance. Such problems, which are illustrative not exhaustive, all require political decisions. These, in turn, require answers to three questions - is it acceptable, it is practical, is it enforceable?

Aircraft noise

Aircraft noise, particularly for those living in the vicinity of airports, has led to increasing concern and protest. The Roskill Commission reviewed the evidence in respect of London's existing and proposed airports and their reports contain a wealth of information about the problem as a whole. The principal features involved in defining the noise field are the orientation of the runway(s) and their extension as flight paths, the noise characteristics of the individual aircraft involved, and the frequency of incoming and outgoing flights. A general distribution diagram of the perceived noise decibel is given in Fig. 1. The highest levels are related to the use of maximum power at take-off and to reverse thrust on landing. The use of two stage flight paths for the approach and the rapid climb at take-off are reflected in the arrow form of the diagram. In reality, the pattern is affected by many factors such as aircraft weight at take-off and, more important, the population within the affected ares. For

comparison, the results of a survey carried out for Manchester (Wood et al, 1974) are presented in Fig. 2.

Technological changes can alter the situation very rapidly however. Although the introduction of turbojet aircraft brought this noise problem to the fore, later generations of jet aircraft have grown progressively bigger and heavier but also quieter. At the same time, the use of noise suppressors, while reducing the overall level, has resulted in a change of frequency which is more penetrating than the original frequencies. Predictions about future levels are unlikely to be accurate as technical innovations are incorporated. The Roskill Commission predicted the levels at Heathrow into the 1980s but already the use of heavier and quieter aircraft has affected this forecast (Fig. 3).

A specific problem evolves from the use of supersonic aircraft such as Concorde. There are questions of noise levels at the ground on take-off but there is also the need to predict the effects of sonic booms. The meteorological factors alone are complex and include altitude, wind sheer, density differentials and flight path among others. To date, the evidence available does not justify condemnation of these simply on the basis of being a noise generator.

Transistor blight.

The third category comprises the disturbance of the peace of one individual to another. Numerous examples could be given but possibly the most widespread form of intrusion is by transistor radios. No longer is it a case of a portable radio in isolated situations for specific purposes; today there is a rash of transistors usually concentrated in public areas or thoroughfares but with sporadic outbreaks throughout the land. These occurrences are merely symptoms of the universal revolution in communications, and particularly the mass media, but they seem to be part of an addictive process. Like many addictions, the withdrawal pains could be acute if this became necessary.

Transistors, together with television and other labour saving devices, all contribute to indoor noise which has not only increased in total but is also more and more concentrated in high density urban dwellings. Like chemical air pollution, indoor values may be greater than outdoor levels. That apart, next door noise is seldom amenable to objective appraisal.

In all three categories there is the common factor that a producer can also be a complainer. Self generated noise is rarely a nuisance to the car owner, the airline passenger or the hi-fi enthusiast. Nor must the positive aspect be ignored or forgotten. Some airlines, for example, provide guides to inflight sights and sounds in order to give reassurance and orientation. As a warning signal, noise is of major importance.

Conclusion

Noise is part of the environment but there is no doubt that in urban areas and in the field of transportation there has been an insidious but marked growth during the last century and particularly during the last two decades. Technological change has been a major factor as developments in transportation and electronics have provided new powerful generators of sound energy. Noise is in many ways a by-product of the age, particularly in transportation, just as increased pollution is an inevitable by-product of the energy explosion.

Interest in the problem is widespread and this would suggest improvements in years to come. There are major institutions engaged on it, e.g. the National Physical Laboratory; there are a growing number of scientific journals devoted to it, of which the most recent (1975) is the Journal of Noise and Noise Control;

there are international congresses with noise as their theme, e.g. the 8th International Congress of Acoustics; and there is the meeting of the Clean Air Society which we are attending. But progress, e.g. in the establishment of noise abatement zones, will be slow and erratic because part of the problem is not, as yet, amenable to objective analysis.

There are three features which distinguish noise from chemical air pollution:

1. The problem concerns the physics as opposed to the chemistry of the atmosphere.

2. It is a local problem.

3. It is largely a subjective problem.

The first lends itself to research and the application of results to specific situations. It will provide the basis for technological change and planning to solve many questions, and it will most possibly go far beyond the physical knowledge required to solve the psychological and aesthetic problems.

The second is double edged. On the one hand it permits a concentration of effort in defined locations, but on the other the economic investment must be justified.

The third is the nub. There are no universal standards to which one might strive. On a global scale, there are vast cultural differences e.g. noise may be the breath of life to a Brazilian; on a national scale, there is constant adaptation to the surrounding environment and since most of the population are urban dwellers their threshold level may not be acceptable to the rural minority; at the individual scale, there is no common factor. Here the answer lies in education and the development of a code of ethics. Such processes are slow to take effect.

REFERENCES

Committee on the problem of noise (Wilson Committee). 1963. Final report. Cmnd 2056, HMSO, London.

TILLOTSON, Howard. 1976. By the Leq : measuring noise nuisance index. Surveyor 147. 27-30

WALLER, R.A. 1974. The assessment of environmental standards. IN COPPOCK, J.T. and WILSON, C.B. (eds) 1974. Environmental quality. Scottish Academic Press, Edinburgh.

WALTERS, A.A. 1975. Noise and prices. Clarendon Press, Oxford.

WOOD, C.M., LEE, N., LUKER, J.A.., SAUNDERS, P.J.W. 1974. The Geography of Pollution. Manchester University Press.

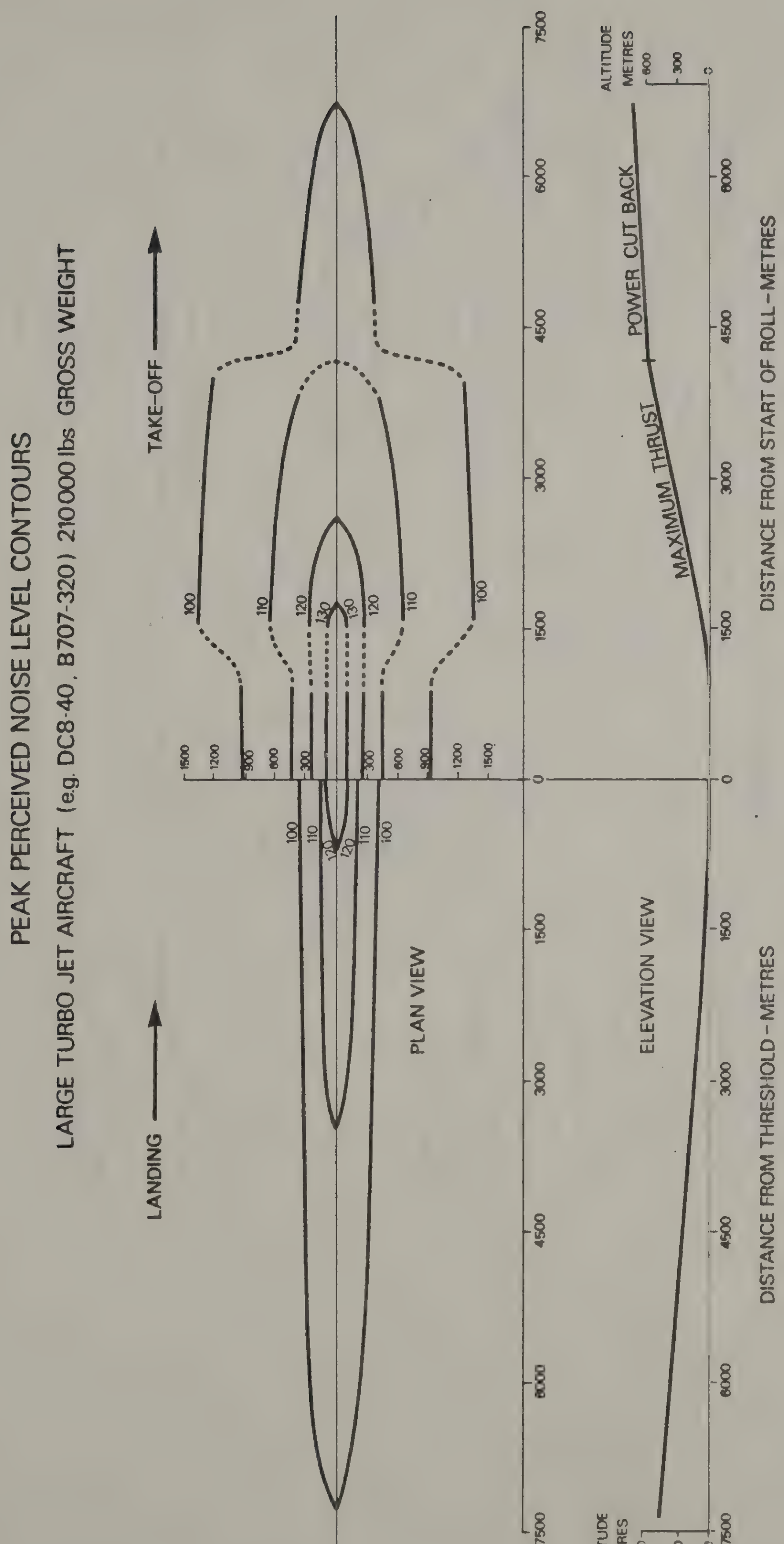


Fig. 1. A generalised diagram of the isophon distribution at an airport.

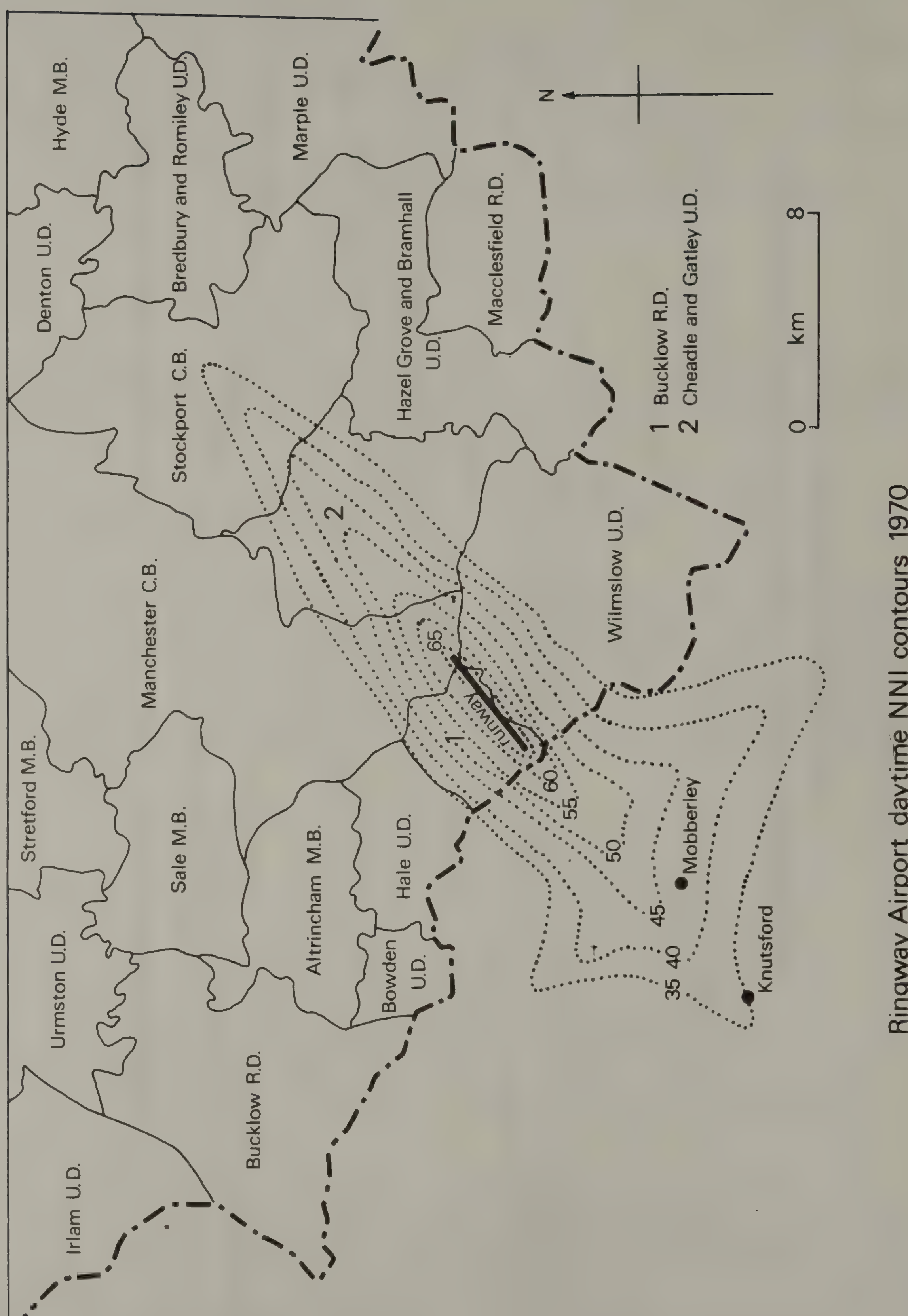


Fig. 2. The NNI contours for Ringway Airport, 1970. (Source : Wood, et al. 1974).

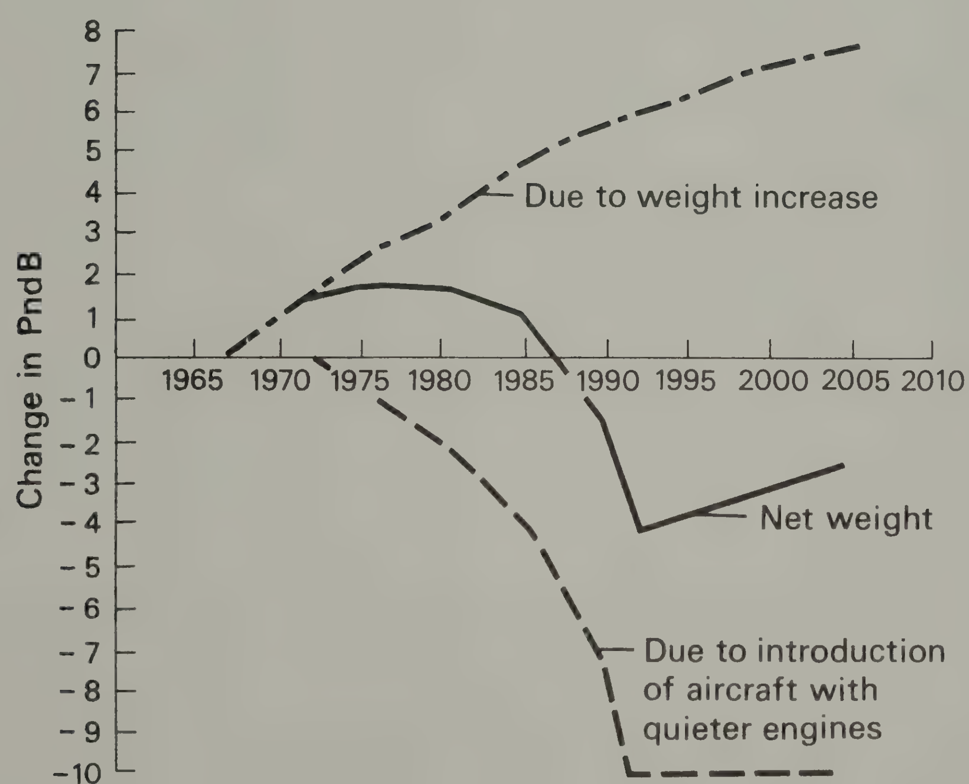


Fig. 3. Prediction of PndB at Heathrow Airport. (Source : Roskill Commission).

43rd ANNUAL CONFERENCE

EDINBURGH

11th - 15th October, 1976

THE INDUSTRIAL AND LOCAL AUTHORITY APPROACH TO NEIGHBOURHOOD NOISE -

by

J.H. Richardson B.Sc.
Senior Consulting Engineer, Acoustic Technology Ltd.

and

R.W. Smith B.Sc.(Eng), M.Sc.(Eng)
Consulting Engineer, Acoustic Technology Ltd.

National Society for Clean Air
136 North Street
Brighton BN1 1RG

1. INTRODUCTION

Maintaining progress in a modern industrialised society inevitably results in an increasing degree of mechanisation of production facilities with associated increases in speed and heavier duties of the equipment involved. Inherently noise levels will rise in a corresponding manner unless specific attempts are made to control the noise sources. In many cases, these noise levels can result in adverse effects ranging from noise induced hearing loss, stress and disturbed sleep to annoyance.

Hearing damage (Reference 1) is more applicable to the working environment rather than the local community and is therefore beyond the scope of this paper. This paper is concerned with the effect of industrial noise on the local community or neighbourhood, and outlines the various methods available for assisting Local Authorities and Industry to reach agreement on controlling community noise; case studies are used to illustrate several points.

2. A BRIEF SUMMARY OF ACOUSTIC TERMINOLOGY

2.1 Sound and Noise

Sound is a sensation produced within the ear, resulting from pressure fluctuations in the air. These pressure fluctuations may, for example, be caused by a vibrating surface, and are propagated in the form of a longitudinal wave motion. The ear responds to changes in pressure, which, over the audible range, vary from the threshold of audibility to the threshold of pain: a ratio greater than a million to one. The audible frequency range is generally between 20 Hz and 20 KHz although this response will vary from person to person as well as with age. As both the ear and engineering materials have a non-linear response to sound energy at different frequencies, it is normal design practice to present sound data as a function of frequency. Usually this is done in the eight octave bands between 63 Hz and 8 KHz where each octave band is denoted by its centre frequency.

Noise is a term generally applied to unwanted or unpleasant sound. In some instances therefore, to one individual a sound would be described as a "noise" while another may describe the same sound as "music"!

2.2 Sound Pressure, Sound Power and the dB Scale

Since the range of pressure fluctuations that the human ear can respond to is so wide, it is inconvenient to express sound levels on a linear scale. It is thus normal practice to use a logarithmic scale, where of course calculations follow the laws of logarithmic rather than linear mathematics. For example, the addition of two equal sound pressure levels would result in an increase of 3 dB.

In practice, if two sound sources differ in level by 10 dB or more, then the addition of the two sources would cause the total sound pressure level to increase by less than 0.5 dB - an insignificant amount. This is a particularly relevant concept when evaluating the degree of noise control required for individual noise sources in a complex situation.

The sound pressure level must always be quoted at a specific location or distance from a noise source, as its magnitude will depend on many factors including distance, source size, directivity and propagation path.

To quantify the total sound energy radiated by a source the concept of sound power level must be used. This is defined as the total amount of acoustic power radiated by a source, and is useful in calculating sound pressure levels at any distance from the source. Again sound power levels are quoted on a logarithmic

scale over a range of frequencies in a similar manner to sound pressure levels.

2.3 'A' Weighted - dBA Scale

The response of the human ear to sound is not linear since the ear is more sensitive to the higher frequencies than the lower frequencies. Therefore there is no direct relationship between subjective loudness and sound pressure levels. However, the internationally accepted 'A' weighting network attempts to make some allowance for the variation in response of the ear, and as such, some measure of correlation between subjective loudness and sound pressure level in dBA can be achieved.

This dBA sound pressure level is the most widely used single figure for quantifying noise levels in an industrial situation. Most sound level meters have an in-built electrical 'A' weighting network, so that the dBA level may be read directly.

The following table helps to quantify noise levels as it relates the dBA sound pressure levels to sources commonly encountered in everyday life.

Source	Location	'A' Weighted Sound Pressure Level
Threshold of Pain		
		130
		120
Chain Saw	Operator Location	110
Discotheque	Inside	100
Heavy Road Traffic	Pavement	90
		80
Average Road Traffic	Pavement	70
Large Store	Inside	60
Typical Store	Inside	50
Residential Area at Night		40
		30
T.V. Studios		20
		10
Threshold of Hearing		0

TABLE I : Typical Noise Levels

It is useful to remember that a change in level of some 10 dB is necessary to either double or halve the loudness as perceived by the human ear, thus a drop of 20 dB would represent a fall to one quarter of the original loudness. By comparison, a 2 dB change is just perceptible.

3. NEIGHBOURHOOD NOISE LEVEL CRITERIA

The assessment of what level of noise causes annoyance, or constitutes a nuisance cannot be quantified by a rigid standard which would be applicable in all instances. (Nuisance is legally defined as a material interference with normal living, bearing in mind the character of the neighbourhood and activities which

would be carried out there.) Therefore a number of different criteria have been developed for different type of source. Amongst these the following items etc. are commonly used to assist in developing suitable criteria for community noise.

The Wilson Report (Reference 2) suggests a range of 50 to 60 dBA during the day and 40 to 45 dBA at night as acceptable noise levels outside residential properties. The range is indicative of the differences between country and urban areas. British Standard 4142 (Reference 3) extends the concept further by applying corrections for the type of district and time of year to a base level, to give a notional background noise level. Comparison of the noise levels resulting from the source of interest with this notional or a measured background noise level. Comparison of the noise levels resulting from the source of interest with this notional or a measured background level will then provide some measure of the likelihood of complaints from the community.

Road traffic noise is limited at source by the Motor Vehicles (Construction and Use) Regulations (Reference 4), which provides maximum allowable noise levels, as measured in accordance with B.S. 3425 (Reference 5) for all road vehicles. Compliance with the Motor Vehicle Regulations, however, will not ensure an acceptable noise level outside of a residential dwelling. Residences affected by traffic noise now have the right to a government grant for double glazing of affected rooms, as defined in the 1975 Noise Insulation Regulations (Reference 6). Whilst these provisions need not necessarily provide relief for those living in well established properties, it does help to establish a criterion for new properties and provide some relief for older properties adversely affected by nearby road alterations.

Recent legislation, in the form of the Control of Pollution Act (Reference 7) has greatly increased the powers of the Local Authority in dealing with many aspects of industrial noise nuisance arising from both the construction of, and day to day running of, any industrial site. Although the majority of the powers and duties relate directly to situations as they exist, the impact of any future development or expansion for which planning permission is sought, must by implication, be considered by the Planning Authority in the light of the Act.

The Control of Pollution Act has laid down the frame-work on which further legislation has been based, for example: the Control of Noise (Measurement and Registers) Regulations 1976 (Reference 8) which require the Local Authorities to register the existing noise levels in and around industrial areas. If then the area in which the development is to take place is included in such a "zone" or register, the limiting noise levels will already be established. Similarly B.S. 5228: 1975 Code of Practice for Noise Control on Construction and Demolition Sites (Reference 9) has been published to provide guidance for Local Authorities and Contractors in establishing methods of meeting realistic noise limits.

Overall the aim of both the Local Authorities and industry is to minimise the number of complaints from the local community, but as the cost of installing noise control measures can be high, industry generally wishes to do what is just sufficient to avoid complaints and possible action by the Local Authority. In such a situation, industry should seek guidance from the Local Authority as to what would be an acceptable level from the relevant plant, and thus it becomes the responsibility of the Local Authority to assess the situation, and using the criteria available establish an acceptable level.

4. NEIGHBOURHOOD NOISE LEVELS

4.1 Neighbourhood Noise Measurement

Problems may arise in some situations where neighbourhood noise measurements

are required. Of prime importance is the weather. Wind, rain and fog all make measurements invalid, and changes in wind direction and temperature gradients cause significant changes in measured noise levels, when compared to the "ideal" calm condition.

Transient noises from sources such as aircraft, passing traffic, animals and children can present a substantial problem when attempting to establish the background level, particularly if an automatic noise recorder is used. As far as possible these disturbances should be eliminated by establishing the mean-low noise level, i.e. the minimum reading on the meter between upward excursions. Alternatively, an L_{90} statistical level provides a useful measure of the background level as recommended in the latest revision of B.S. 4142. The L_{90} noise level is that level which is exceeded for 90% of the time.

Having established the background noise level, the measurement of the offending source can be made in a number of ways. The simplest method is to take a visual mean maximum level from the meter. With more sophisticated equipment the L_{10} noise level estimate (i.e. that noise level exceeded for just 10% of the time) or the equivalent noise level (L_{eq}) as used in B.S. 5228 may be measured. The method adopted will depend on the equipment available and the criteria to be used. There are also a number of specialised systems adopted for aircraft, impact noise etc.

It is probable that the L_{eq} level will become widely accepted, although there is not a complete correlation between L_{eq} and annoyance for all types of noise source. The advantage of the L_{eq} is that account is taken of the limited duration of intermittent sources.

Whatever measurement system is adopted, it is essential that it is adequately calibrated both before and after each measurement, as experience has shown that under many conditions, moisture or dust in the atmosphere can affect the performance of the instrumentation. Significant variation would, of course, invalidate any readings or recordings.

4.2 Neighbourhood Noise Prediction

When planning permission is sought for a new project, or an expansion to an existing plant, it is often necessary as part of that application to predict the impact of the noise from the plant at the local community. To make such a prediction, the sound power level(s) of the source(s) and the sound propagation characteristic between the source and the community must be known. The sound power levels may be obtained from the plant vendor or from prediction techniques. Whilst the precise propagation characteristics will depend upon the atmospheric conditions, as well as the physical features of the area, for most practical purposes, the still air condition may be assumed. Thus for a very short period during the year, the measured noise level could be greater than predicted. A typical variation over the year of noise levels from a large process plant is shown in Figure I, although the variations in propagation may not solely account for the differences. The OCMA Specification (Reference 10) provides standard procedures for the prediction of the effects of distance, molecular absorption of air, and ground effects on the propagation of sound, and it can be generally applied to large works or plants. If specific local screening is present, for example a wall or building in close proximity to the receiver, then the appropriate corrections can be obtained from the OCMA document.

Road traffic noise and its propagation can be predicted from The Calculation of Road Traffic Noise (Reference 11). Such predictions form the basis for payment of compensation under the Noise Insulation Regulations 1975. The Noise Insulation Regulations also serve the purpose of defining a maximum acceptable

level of external noise for residential areas, although consideration should also be given to the resulting internal noise level.

In a few cases it may be considered that the exceptional topographical or meteorological conditions make the application of standard prediction techniques doubtful. In such cases a propagation study could be conducted. Typically, a study would involve the use of a high power noise source (e.g. a siren or ship's horn) located in the centre of the proposed works, and noise monitoring stations located at representative positions in the neighbouring community. The difference in noise level between the source monitor and the neighbourhood, computed for the frequency range of interest (generally 63 Hz to 8 KHz) gives the actual attenuation for that particular distance and direction. To obtain meaningful results, it is necessary to repeat the procedure over a considerable period of time to ensure that the tests include a representative range of weather conditions. The procedure is therefore relatively expensive and could only be justified if conditions were critical, or if the plant owners thought that standard procedures were under-estimating the attenuation. By presenting proof of the additional attenuation to the Authorities, a reduced noise control programme could be adopted for the project, thus reducing capital expenditure.

4.3 Neighbourhood Noise Assessment

The measurement and/or prediction of both the background and the source noise levels could be conducted by either the Local Authority or the plant owners and it is probable that both parties could reach agreement with the minimum of discussion. Once both parties have agreed to the results of the measurement or prediction it is necessary to assess the community reaction and hence the degree of source noise reduction required. A typical guide to community reaction is shown in Table 2.

Excess dBA (based on accepted corrections)	Estimated Community Response
0	No observed reaction
5	Sporadic complaints
10	Wide spread complaints
15	Threats of community action
20	Vigorous community action

TABLE 2 : Estimated Community Response to Noise

However, the assessment of any noise reduction measures that may be required to satisfy the community cannot always be readily agreed by both parties, and considerable effort may be required to obtain a mutually agreeable solution.

Where noise sources have a particular characteristic or occur at irregular intervals, the problems of agreement become even more acute. For example, in a recent court case where an action was brought by a neighbour to reduce the noise levels radiating from an adjacent zoological garden, both parties agreed on the measured noise levels, but one party described the noise as subjectively

"like a noisy piece of machinery badly in need of lubrication" whereas to the other party they were just bird calls!

It is unlikely that any one of the existing community noise criteria, or any simple criteria that may be developed in the future could be applied to accurately assess community reaction under all circumstances. Where correction factors and human variation have to be accounted for, there will generally be scope for disagreement between two sides in any dispute.

Naturally, when problems do arise, the representatives of the community wish to have as low noise levels as possible. Conversely the plant owners (or vehicle owners etc.) wish to minimise expenditure, while still remaining good neighbours and without risking an action which might restrict their operations. The Local Authority is in the unenviable position of being in-between the two sides. It must represent the local people, and defend them if there are genuine grounds for complaints, and yet retain an understanding of the needs of the industrialist on whose continued production the economic stability of the area may depend. Thus the Local Authority must protect the industrialist from eccentric, frivolous or otherwise unuustifiable complaints from members of the community.

In some instances it is possible that there is no solution to the community noise problem that would be economically acceptable to the works concerned. Typical of such a situation is the problem where originally the works were in a relatively isolated area, but since the initial planning consent was given residential development has been allowed to approach the works boundary. The obvious solution would have been to allow for residential expansion by imposing realistic noise limits on the works at the outset. This type of problem emphasises the need for environmental noise to be considered for all planned developments.

5. NEIGHBOURHOOD NOISE CASE STUDY SUMMARIES

The following case studies are presented as illustrations of the way in which the problems of neighbourhood noise have been tackled by both Local Authorities and "Plant" owners, with the advice of noise consultants. The solutions adopted include the use of noise control hardware, modifications to site layout, changes of operating times and procedure etc.

Case I Grass Roots Refinery Project

An application for outline planning permission to build an oil terminal with refinery and storage facilities was received by the Local Planning Authority. The Authority was very concerned about the environmental impact of the project, including air and water pollution, visual intrusion and neighbourhood noise levels.

The Local Authority decided to appoint consultants to assess the impact of the proposed refinery complex on the local community. Accordingly, a comprehensive study was undertaken. This study for the Local Authority included a background noise survey, predictions of noise levels from the plant both during construction and during normal operation, and recommendations for generally improving the site layout in order to minimise the noise impact.

The first application was refused on a number of grounds, one of which was the lack of detail and consideration to the noise impact. As a result of this decision it was recommended by the Authority that their consultants should work with the applicants to derive the optimum plant layout. The resulting modifications reduced the estimated noise levels by 10 dBA (halving of the subjective loudness) in one locality and 3 dBA at another; in this instance the two critical community locations were diametrically opposed. The rearrangement included positioning of the process area at a lower elevation, thus increasing

the allowances that could be made for ground effects; positioning the workshops and offices between the process area and one sensitive community area and positioning all the furnaces, which were a major noise source, at the rear of the process area, thus obtaining the maximum possible screening effects.

The revised application, which included the majority of the recommendations made on environmental grounds was granted approval, subject to conditions which would limit the environmental impact to an extent which was considered acceptable by the council and its advisors.

Case II Dredging Noise

Dredging was required for a deep water berth and turning bay for a new oil terminal. To meet the required completion date and to utilise the dredger to maximum advantage (and thus reduce costs), the dredging operation was conducted on a non-stop 24 hrs/day basis. For the majority of the time there was no noise problem as the dredger was either working well offshore or else the weather conditions provided adequate attenuation. However, on some occasions the noise produced by the dredger caused numerous complaints - the noise included characteristic tonal and impulsive components which added considerably to the annoyance factor.

The problem continued and the Local Authorities wrote to those responsible requesting that the noise nuisance should stop. It was subsequently agreed that while the dredger was in operation close to the shore-line, noise levels at selected locations would be monitored by both the council and the dredging company. If on any occasion the corrected measured level exceeded that which was considered to be acceptable (60 dBA), those in charge of the dredging operation would be informed, in order that they could take action to abate the nuisance. In addition, the possibility of reducing the noise emitted by the dredger was investigated and noise control recommendations made, but any measures would have reduced necessary access and would reduce the availability of the dredger. Therefore this line of action was not considered further.

The solution was, that both the Council and the dredging company had reached an understanding as to each other's problems and a reasonable compromise had been reached.

Case III Night Club

An entertainments centre in a holiday location applied for an extension to the licensing hours for music and dancing, but local residents raised objections to the application on the grounds of potential noise nuisance. The club owners wished to show the authorities that steps had been taken to reduce the neighbourhood noise to generally acceptable levels. Consultants were appointed to assess the existing situation and make recommendations where necessary to alleviate any problems.

Accordingly noise measurements were taken in and around the premises whilst music and dancing were taking place and the background level was established when there was no music. For comparative purposes additional measurements were made in the vicinity of similar nearby establishments.

Analysis of the results showed that while live groups were performing, complaints would be justified from some local residents. However, simple modifications to the night club - the bricking up of several windows and improved sealing around doors, would reduce the radiated noise to an acceptable level.

Another source of complaints was from the noise generated by patrons leaving the premises, particularly from cars in the car park. No practicable noise control hardware could be used to reduce the noise from this source, and thus notices were

posted requesting the patrons to leave the premises quietly.

Case IV Oil Terminal Pumping and Storage Facilities

A major oil company applied for planning permission to construct an oil terminal located on the coast and a storage and pumping station located inland. The site selected for the terminal was adjacent to an existing chemical plant and thus no major environmental objections were anticipated. The site for storage and pumping station, however, was in a typical "grass roots" location with no industry or other major noise sources nearby - the background noise originating from light local traffic, farm machinery and animals. Thus it was anticipated that the local inhabitants would oppose the project on grounds which would include noise nuisance. The company appointed consultants who established the existing background noise levels in the areas around both sites and recommended acceptable increases in noise levels due to the operation of the plant. An outline noise control study was undertaken to demonstrate that the levels proposed were attainable.

The overall package was finally accepted by the Local Authority and the plant constructed. Throughout the project consultants representing the council and the oil company kept in close liaison to ensure that the overall object of minimising the impact of the neighbourhood was achieved.

Case V Sand and Gravel Extraction Site

Permission was sought by a sand and gravel company to extract from a site which had previously been agricultural land. Objections were anticipated from local residents and a nearby hotel which partially overlooked the site. Workings of this nature are generally opposed by the surrounding community and thus the company wished to present a scheme to the authorities which would minimise the impact, yet maintain the economic operation of the project. With the assistance of noise consultants a working scheme was devised which met the required objective.

A gravel pit may either be worked dry or wet, depending upon the height of the water table. In the case in question, the pit was to be worked dry, which would result in potentially higher noise levels. The proposed scheme was generally as follows.

a) The preliminary top cover would be removed and used to produce an acoustic bank to shield the most sensitive community areas.

b) The washing and grading plant would be built below ground level, thus obtaining maximum screening from the sides of the pit. Initially, the gravel could be processed at a nearby works before the washing and grading plant was built.

c) The main excavating equipment and the site transport vehicles would all operate on the bed of the site at a depth of about 6m, to obtain acoustic shielding from the sides.

d) The pit would be continuously back filled to maintain a constant "source to barrier" distance and hence keep the attenuation effects relatively constant.

e) All mobile engine driven plant would be effectively silenced and where possible, static plant would have inherently quiet electric motor drivers.

The estimated effects of the overall operation are considered to be generally acceptable, with the levels of community noise anticipated to be the highest during the initial construction of the acoustic banks. This will occur only for a short period, during which the noise will still be less than the L_{eq} of 75 dBA

considered acceptable by B.S. 5228 (Reference 9).

During normal operation and production on the site, the noise levels at the community would generally be less than the existing levels. (The background noise is at present influenced by a motorway and an international airport.) Only for limited operations would the noise level exceed the existing background level, and then not by more than a few dBA. It is anticipated that planning permission will be granted in the near future.

Case VI Chemical Plant Expansion

This case illustrates the changing situation with regard to noise legislation and environmental attitudes over the last ten years.

Ten years ago, when complaints were first received, the plant was situated in an area of low-density residential development. At this time the only criteria against which the alleged noise nuisance would be assessed was the Wilson Report (Reference 2). Because of the 24 hour operation and the residential nature of the area, it was agreed that the longterm aim should be to reduce noise levels at the boundary to 35 dBA. Measured noise levels lay in the range 42-54 dBA. Despite some noise control measures being implemented, it was not possible to reduce the maximum noise levels below 45 dBA, but since complaints ceased no further action was taken.

During the period 1965-1970 considerable changes occurred. These included a take-over of the plant by an international company resulting in a major expansion programme, together with permission being granted for a new housing development close to the plant boundary. There was subsequently an increase in the incidence of complaints, some of which were directed at discrete sources, particularly those having tonal or impulsive noise characteristics.

A survey in October 1970 confirmed that noise levels had increased to over 50 dBA. It is considered that weak planning control, in respect of noise, during this period was responsible for most of the problems. In order to reduce the noise level and hence the number of complaints, it was agreed with the Local Authority that the British Standard 4142 (Reference 3) should be used. Background noise levels in the absence of plant operation could not be obtained and therefore a criterion level of 45 dBA was established by the calculation method. Attention to the new noise sources reduced the plant noise level in the community once again to 45 dBA.

A further expansion was planned in October 1974, but by this time the Planning Authority were able to stipulate that the new expansion should not cause an increase in the community noise levels and should be such that a long term goal of 40 dBA could be achieved. These conditions were consistent with the recommendations of the Control of Pollution Act (Reference 7).

By careful design and considerable expenditure it was possible to install the new plant in such a way that it would produce noise levels of less than 35 dBA at the boundary. Recent measurements have confirmed that no increase in noise levels have occurred with this new plant in operation.

To summarise, the powers given to the Local Authorities have resulted in containing the noise nuisance such that, despite major plant extension and additional residential development, the noise levels at all community locations are now less than those measured in 1965. There is, however, still scope for further improvements, and an encouraging step has been the recent formation of a committee composed of representatives of the Local Council, the Company and the Residents Association, which will meet regularly to monitor all aspects of pollution (noise, smell vehicle movements etc.). Hence, the interests of all parties may be considered.

SUMMARY

From the preceding sections of this paper it is apparent that a great deal is now being done to reduce the incidence of noise nuisance in the community arising from industrial sources. Legislation is providing the Local Authorities with greater power to advise on the implementation of noise control schemes on existing sites; but perhaps an even greater benefit is the introduction of an awareness to both the Local Authorities and industries, of the need for noise control at an early stage of planning, particularly for long term planning. Furthermore, Standards and Codes of Practice are now being introduced to provide both parties with definitive criteria on which to base their plans.

REFERENCES

1. Code of Practice for Reducing the Exposure of Employed Persons to Noise, H.M.S.O. 1972.

2. Noise - Final Report, H.M.S.O. 1963.

3. Method of Rating Industrial Noise Affecting Mixed Residential and Industrial Areas, British Standards Institution 4142 : 1967.

4. The Motor Vehicles (Construction and Use) Regulations, 1969.

5. Method for the Measurement of Noise Emitted by Motor Vehicles, British Standards Institution 3425 : 1966.

6. Statutory Instrument No. 1763 : Building and Buildings. The Noise Insulation Regulations 1975.

7. Control of Pollution Act, H.M.S.O. 1974.

8. Statutory Instrument No. 37, 1976 - The Control of Noise (Measurement and Registers) Regulations 1976.

9. Code of Practice for Noise Control on Construction and Demolition Sites, British Standards Institution 5228 : 1975.

10. Procedural Specification for Limitation of Noise in Plant and Equipment for use in the Petroleum Industry, Oil Companies Materials Association Specification No. NWG-1 (revision 1) 1972.

11. Calculation of Road Traffic Noise, H.M.S.O. 1975.

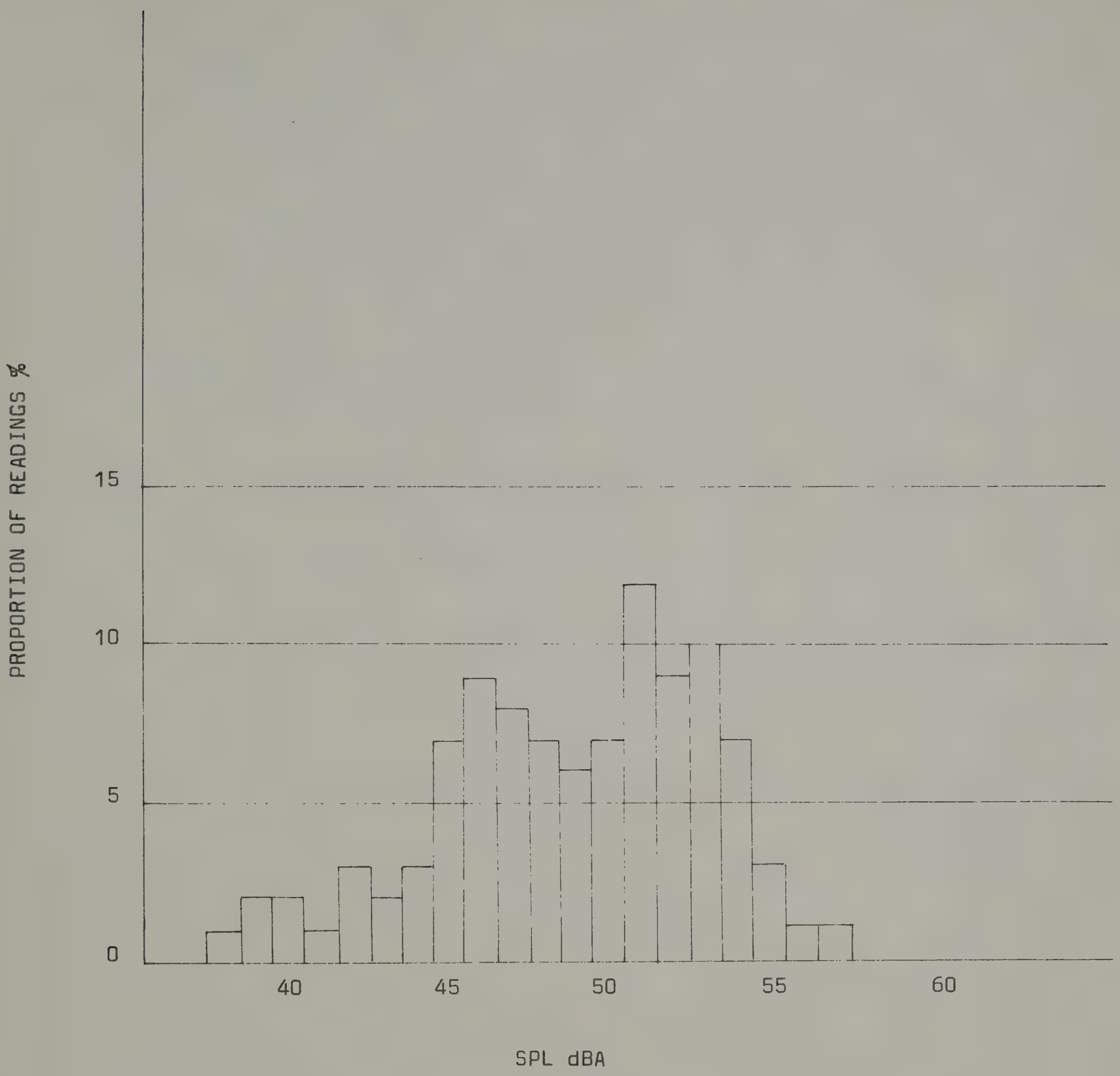


FIGURE I : Histogram of Daily Noise Level Readings Taken at a Fixed Point in the Neighbourhood of a Refinery Over a Period of a Year

43rd ANNUAL CONFERENCE

EDINBURGH

11th - 15th October, 1976

SMOKE CONTROL -
A REVIEW OF THE PRESENT POSITION
AND THE WAY AHEAD

by

W.J.S. Batho
Department of the Environment

National Society for Clean Air
136 North Street
Brighton BN1 1RG.

It will of course come as no surprise to the 43rd Clean Air Conference to learn that, in the interval since a member of the Department of the Environment addressed the 40th Annual Conference in 1973 on the subject of smoke control, times have got much more difficult. Three years ago the energy crisis was just beginning to emerge as the successor to the environmental crisis. The financial crisis which has substantially overborne both of them in recent months - at any rate in the public mind - was even more remote.

With so many crises to threaten our ordinary lives it would not be surprising if there were not those who, addressing themselves to problems of smoke control, had not soliloquised in something like the following vein:

> "We have had smoke abatement policies for many years and a smoke control programme for the better part of twenty. A great deal has been done both to ensure that smoke control is effective and to see that the old days of smog and pea soupers never return. Former black spots like London and Sheffield are now shown to admiring foreigners as examples of what the British can do to solve their domestic problems if they set their minds to it. That being the case should we not now draw in our horns and perhaps close down the smoke control programme at any rate for a few years until the country's financial affairs have been stabilised and we can once again afford to indulge in such luxuries as programmes of environmental importance?"

I doubt whether I would be believed if I sought to assure this Conference that such siren voices had never been heard in the corridors of Whitehall. A period of financial stringency is a great time for looking at priorities and, as members of this Conference will appreciate, environmental questions, including smoke control, have had to come under scrutiny with everything else. It is therefore gratifying to be able to state, in the words of Mark Twain, that the report of the death of the smoke control programme was an exaggeration.

How much of an exaggeration can be demonstrated by the following statistics. In the last three years the number of smoke control orders submitted and the number of acres and premises which they cover have been as follows:

	Acres	Premises
1973/4	135,000	478,000
1974/5	85,000	282,000
1975/6	87,000	257,000

The cost of smoke control to the public in these years, that is the combined total of grant paid by central and local government has been:

1973/4	£4.6m
1974/5	£3.5m
1975/6	£4.3m

It is worth pointing out that the most we ever spent on these grants was in the retrospectively halcyon year 1967/8 when the total sum amounted to £5.2m - although admittedly one got considerably more for one's pound in those days.

But these are merely statistics and they do not indicate very clearly the answer to the real question of how much of the work envisaged as necessary by the Beaver Committee in 1954 has now been completed. In his Report Sir Hugh Beaver divided the country into black and white areas and although such a division was even then contentious it signified those areas where the production of smoke together with the climatic conditions appropriate for the formation of mist or

fog made the production of smog a serious possibility. The black areas in other words were a way of indicating the high risk areas for the kind of smog which occurred in London and which in the course of a few days led to the death of some 4,000 people. Obviously the corollary of dividing up the country in such a way was to seek to ensure that smoke control was introduced in these high risk areas as a matter of priority.

How Have We Done

It would be nice to be able to say that of the black areas envisaged in the Beaver Report all are now subject to smoke control orders but that is not the case. There are two main reasons for this: one significant and one relatively trifling. The trifling one is the fact that the rules were changed some time ago at the time of local government reorganisation, so that the definition of the old black areas in the light of recent smoke control orders becomes more and more an academic exercise. Nevertheless we estimated that at the time of local government reorganisation something like 70 percent of black areas were subject to smoke control orders and we reckon that the present figure, in so far as it can reconstructed, would approach the 75 percent mark.

The more serious reason why a sizeable proportion of black areas remains to be dealt with is that progress throughout the country has been very uneven. London, for once a model of virtue, is as near as makes no odds completely covered by smoke control orders and the results are obvious for all to see. The situation is very different in some other parts of the country. This is a matter which has exercised the Clean Air Council very seriously over recent years and following the reorganisation of local government all local authorities were asked to send details of progress made so far in smoke control in their areas and to indicate what their long term targets were. The following table sets out the latest information available.

PREMISES ('000s) COVERED BY SMOKE CONTROL

REGION	30 JUNE 1976	INCREASE SINCE REORGANISATION 1 APRIL 74	% OF TARGET SO FAR ACHIEVED *
Northern	454	77	46
North West	1381	91	64
Yorkshire & Humberside	1040	63	62
West Midlands	684	88	43
East Midlands	389	51	39
East Anglia	22	5	12
South West	96	19	34
South East	508	78	42
London Boroughs	2837	110	94
TOTAL	7411	582	61

* The target does not relate to the old black areas. It represents the number of premises in each Region which local authorities themselves propose to bring under smoke control, and the percentages given indicate progress so far.

Possible Reasons for Regional Variation

It is very difficult to be sure why there is such wide variation throughout the country. The importance of effective pressure from enthusiastic local authority members and officials is obvious and the success of the introduction of smoke control in Sheffield - which owes a very great deal to this kind of pressure - shows what can be done. But there remains the difficult question of why this sort of pressure should be more widespread in London and the South East than it is in, say, the North East or the North West.

One can of course discount the notion that if people are used to something, however bad it is, they will rather put up with it than change it. London and Sheffield are obvious contradictions to this theory and it is in any case ludicrous to suppose that anybody actually likes smoke polluted air. The reasons seem more likely to be economic and in some parts of the country at least directly linked to a specific industry.

The most obvious and widely quoted of these links is that with the coal mining industry. The fact that miners receive what is known as "concessionary coal", that is an allowance of coal at very much below the market cost, is sometimes thought to be the reason why smoke control has proceeded more slowly in coal mining areas that in some other parts of the country. But there is really more to it than that. The concessionary coal is a valuable perquisite which goes with the job but there is also the feeling which exists in mining communities that smoke control might have an adverse effect on the coal mining industry as a whole since it might lead a lot of people to switch from coal to some other form of fuel. To that extent therefore the view that concessionary coal is what holds back the implementation of smoke control in these areas misses most of the point. The chief cause of hesitation is a feeling, however misguided, that a mining community which does not impose smoke control measures is making a gesture towards the continuing importance both of the local pit and of the coal mining industry itself. Once it has been decided to operate smoke control measures in a coal mining area the National Coal Board has a scheme to subsidise the use of smokeless solid fuel in place of the concessionary coal but the main obstacle seems to be not the detailed terms of such a scheme but rather the deep-seated feeling that to go on using coal is bound up with the mining community's future wellbeing.

There are other areas of the country where the gradual decline of traditional - and labour intensive - industries has led to an urgent need to concentrate public attention and resources on industrial regeneration and on finding new sources of wealth. In areas where the major priority has been the creation and saving of jobs it is hardly surprising that environmental improvements have not always been given high priority. But the effort continues and thanks to the continued exhortations of bodies such as the National Society for Clean Air I think we can now detect a growing awareness of the importance of improving the quality of the environment even in areas with substantial economic problems.

What Should Central Government Do?

It is worth spelling out some of the possible local reasons for reluctance in going ahead with smoke control, both because these are important considerations in themselves and also because they are the sort of thing which it is very difficult for central government to know in detail. We know about smoke control orders which are to be implemented (indeed the Secretary of State has to confirm each one and must therefore be fully informed of what is proposed) but we don't, and as things area, cannot know why a local authority has not brought in an order. We do not require explanations of why a local authority has not used a discretionary power and so can only guess.

There is a very real point of principle underlying all of this. Despite what

sometimes must look like evidence to the contrary, the Department of the Environment does think that decisions which will have a major effect upon local communities should be taken by those communities without undue pressure from the centre. The temptation of administrative tidiness - for example to get all England or at any rate all urban parts of England 100 per cent smoke controlled - is a real one but it must be resisted, even if it spoils the uniform coloration of a map in a DOE office somewhere. A northern moorland area is different from Sheffield or Hammersmith and we would do well in the Clean Air Division of the Department of the Environment and elsewhere to have this formula constantly on our lips. But having said that, we need to ask whether we can so order our affairs that, without dictating to those who have so far resisted the blandishments of the smoke control programme, we can persuade them of its merits.

Locally Determined or Key Sector

In order to consider whether there is anything which Whitehall might reasonably do to assist local authorities in the task of coming to a decision on their smoke control programme I have to undertake a brief excursion into the way in which we nowadays support local authority capital programmes by assistance from central government funds, that is the Rate Support Grant. Smoke Control Programmes come into this category because the grant which is made to each householder to help him pay for the new appliances to replace his old smokey fireplaces and stoves comes partly from central funds and partly from local authority funds. That element which comes from central funds has not so far been a problem. We have never yet had to refuse to confirm an order because we had run out of money to pay our share of the grant and I can see no likelihood of that situation arising.

The problem arises on the local authority side. Because of our very proper determination to ensure that local issues are settled locally the DOE has tended to move increasingly in the direction of providing a sum of money to local authorities out of which they have to fund a variety of different kinds of scheme. Projects which fall into this category where the choice is that of the local authority, are known as Locally Determined Schemes and it is for the authority itself to decide whether it wishes to spend its money on say the building of a new swimming pool or providing bus passes for old people or the setting up of another smoke control area. An arrangement of this sort - which postulates of course that there is never enough money for everything - leaves the local authority with the difficult choice of deciding between competing (and all desirable) projects. It is in this context that the particular enthusiasms of the chairmen of Public Health Committees or of senior local authority officials are of great significance.

But the critics of this arrangement as it affects smoke control reasonably point out that the enthusiasts for this form of expenditure have had 20 years to put their point across. In the places where there has been real stomach for the fight the battle has already been won but elsewhere it can be argued that relatively little progress has been made because smoke control has consistently been seen as less important than other forms of expenditure and is likely in the future also to lag behind. So long as these arrangements remain unaltered, say the critics, so long shall we have a marked difference between those areas which have already taken the opportunity to introduce smoke control and those which the DOE representative who addressed this Conference some three years ago was bold enough to refer to - indeed identify - as "laggard" authorities.

The critics do not only point to the drawbacks of the present arrangement: they suggest a remedy. They point out that local authorities do not only receive grants for Locally Determined Schemes but that there is another category called Key Sector schemes which are financed rather differently. In this case schemes are subject to specific approval either as blocks of expenditure or individual projects, so that a local authority gets a sum of money to fund a particular scheme and there is no question then of the local authority's having to make up

its mind whether to spend the money on that project or something else. Let us, say the critics, therefore put expenditure on smoke control into the Key Sector category and local authorities will have to spend money on that or else not use it at all.

There is of course force in this argument. It has been extensively considered in the Department and there seem to us to be two main objections. The first is the important one of principle: local authorities should be trusted to make their own decisions. This is particularly true in matters such as the setting up of smoke control areas where all sorts of factors have to be taken into account. Is it an area containing a lot of elderly retired people, for whom the change might be singularly unwelcome and costly? Do the local geographical conditions give more or less urgency to the scheme? What is the pressure on the authority's financial resources for other projects? These are the sort of things which a local man would know by instinct but which a bureaucrat in Whitehall might get very wrong indeed no matter how conscientious his examination of the papers.

But there is another consideration as well. Nobody would suppose that Key Sector schemes go through on the nod or that there are limitless resources available to finance such expenditure. It is possible indeed that the amount of money allocated to smoke control in the Key Sector would be less than the money available in total under the locally determined arrangement because of the claims of other Key Sector items. The drawback as it seems to us would be that the decision would be made centrally rather than locally. And of course even if money were available in the Key Sector we still would not be able to dragoon unwilling authorities to undertake smoke control schemes in their areas, although we might perhaps be able to tempt them with the offer of money which they would otherwise not receive. But either way there would be much more control and consultation at the centre and correspondingly less locally and for that reason we have resisted suggestions that smoke control should be transferred to the Key Sector.

Role of the Clean Air Councils

It would not be right to conclude the review section of this paper without a word about the Clean Air Councils which for 20 years have kept a close watch on the development of smoke control in England and Wales on the one hand and in Scotland on the other. Since I am the Secretary of the Council for England and Wales I shall concentrate on the work of that Council but as people in Scotland know well the Scottish Council is just as assiduous in encouraging action against atmospheric pollution north of the border as we are south of it.

The Councils were established when the 1956 Clean Air Acts came into operation. They were constituted under that legislation and inevitably the main thrust of their work for the first two decades of their existence has been concerned with the encouragement and continued development of domestic smoke control. It has been immensely valuable for government to have the advice of people representing a wide range of industrial and local authority opinion as well as other interests as the smoke control programme has developed. It has provided an opportunity for focusing opinion particularly at times when the programme itself has run into difficulties. There is perhaps no need to go into details of struggles which have been successfully concluded or of compromises which have been successfully negotiated. A look backward from the present day to 1956 shows just how many crises of one sort or another have had to be surmounted and it is thanks in no small measure to the work of these Councils that the programme has continued to make steady progress.

In this context I should like to refer to the Beaver Memorial Lecture which was delivered by Lord Ashby to a meeting of the National Society for Clean Air on 3 December 1974. In the course of this lecture Lord Ashby stressed the importance of the social context of any reforming measure like the Clean Air Act. This did

not after all spring fully grown from the collective head of Sir Hugh Beaver and his Committee. There had been other attempts to introduce clean air measures but the difference was that by 1956 the public mood was receptive to the concept. Not the least function of the Clean Air Councils has been to cultivate and encourage that mood so as to ensure that the impetus that was imparted in 1956 does not run out before the clean air programme has been completed.

It would be presumptuous of a mere Secretary of the Council to speak too glowingly about that Council's future but I take great encouragement from the fact that so many members of the National Society for Clean Air are also members of the Clean Air Council. Quite recently the Council has itself been somewhat reorganised so that it can better address itself to a wide range of problems which are likely to arise in the future. A system of Standing Committees has been established and of the four Committees two are chaired by members of the National Society and all of them benefit from the inclusion among their membership of people who are also members of the National Society.

The Way Ahead

I have dealt at some length with current problems because these are still much the same sort of problem that we have been grappling with for the past 20 years but I suspect that we are at or very near to a point of great importance in our attitude to and method of dealing with smoke control. This arises directly from our decision to join the European Economic Community and from the Community's interest and involvement in air pollution matters.

Again a brief digression, this time on the way in which the Community machinery works, might be of some assistance. In the environmental field, as in many others, the Community's will is often expressed in the form of Directives which once they have been adopted by all Member States become legally binding on those States. This procedure has already begun with Directives on various environmental problems associated with water and we are now moving to the point at which we can expect further Directives in connection with atmospheric pollution and noise. Indeed there is already one Directive dealing with the sulphur content of gas oil which has been adopted but because the gas oil in use in this country generally has a low sulphur content this Directive is not likely to make any great impact, at any rate for some years to come.

The process of creating a Directive is lengthy. Before any proposal for a Directive goes to the Council of Ministers for consideration there is usually a period of discussion by both officials of the Member States and 'experts' - the inverted commas are not intended to be pejorative but simply to indicate that expert is in itself an inexact term, and the discussion and consultation therefore include a wide range of interests. After this the Commission produces its first shot at a draft directive on the chosen topic. This draft is submitted to the Council and it is extensively commented on and discussed at meetings of officials of the Member States in Working Groups of the Council. It generally goes through several drafts and eventually a revised version, which it is hoped will be acceptable to all Members States, is submitted to Ministers for endorsement. It is at this point that failure to agree by any one Member will prevent the adoption of the Directive, but if this is avoided the Directive has to be implemented in each Member State.

There are at present several Directives with a bearing upon smoke control which are at various stages in this process. The most significant of these in this context is a Directive on Health Protection Standards. In brief, this Directive will require Member States to take measures to reduce the amount of particulate matter and SO_2 in the atmosphere to specified levels. This concept which is near to the concept of guidelines recommended in the Fifth Report of the Royal Commission on Environmental Pollution has all sorts of implications for the British philosophy on the control of atmospheric pollution but I propose briefly

to concentrate upon the implications for smoke control.

The first thing to be said is that so far as we can judge at present in many parts of the country the requirements of the Directive as regards particulate matter will be at least as important as those concerning SO_2. In such places the introduction of smoke control areas where they do not already exist will be both the most effective and the cheapest way of meeting the requirements of the Directive. Elsewhere, particularly where smoke control areas are operative but the SO_2 requirements of the Directive have not been met, other measures will be necessary. But in many places the implementation of smoke control under the terms of the Clean Air Acts would do all that was necessary.

The significance of this is obvious. If this Directive comes into operation - and there is support for it among our EEC partners - the British Government will have an obligation to meet the requirements. At this point the Government will have to consider whether the present administrative arrangements will be sufficient, or whether some more positive direction from the centre will be required.

All of this is of course highly speculative. We are so far only at the stage of having seen the first draft of this Directive and it is clear that a great deal of work needs to be done on it before it is acceptable to the United Kingdom. But the wider implications in terms of atmospheric pollution control which arise from our decision to join the Community are now emerging. We have a high reputation among our EEC colleagues for the work we have done on air pollution control in the past; the Clean Air Acts are extensively studied and admired; the good work of local authorities is well known, not least because of the policy of the National Society for Clean Air in sponsoring conferences such as this one. Above all, our European partners recognise that we have contrived to deal effectively with a pollution problem which was as notorious as it was traditional. To that extent therefore we are still seen as an exemplar and it is thus fitting that the next stage of smoke control in this country should arise directly from our international commitments and that the programme of work which was begun more than 20 years ago will be concluded in company with our European partners.

43rd ANNUAL CONFERENCE

EDINBURGH

11th - 15th October, 1976

SMOKE CONTROL IN AN INDUSTRIAL AREA;

EXPERIENCE IN NORTH EAST ENGLAND

by

L. Mair, F.R.S.H., F.E.H.A.
formerly Director of Environmental Health
City of Newcastle upon Tyne

National Society for Clean Air,
136 North Street,
Brighton BN1 1RG.

1. PREAMBLE

It could be said that the practical advantages of experience exist only if those advantages can later be used in the same or a similar situation. To gain a sense of satisfaction at the completion of a smoke control programme is purely a personal gratification which, in itself, can have no practical application in a "one off" situation such as is constituted by securing the abolition of avoidable domestic smoke. Moreover, in looking back over the past two decades or so, it does not seem to me, having regard to the financial and legal constraints and other prevailing and changing conditions which obtained during that period, that I would tackle and carry out the task in any manner significantly different from the way it was carried out, at least so far as my own local authority is concerned.

Therefore, the only justification which I can contrive for writing and submitting this paper is that the experience gained in the North East generally and in Newcastle upon Tyne in particular may be of interest to the protagonists of pollution abatement and possibly, but perhaps with less optimism, that in some way it may be of some usefulness if applied to those areas where smoke control is in its infancy or where it has yet to begin.

I, therefore, propose to examine the situation which existed in 1957 when smoke control as a procedural and practical operation was initiated in the North East and to comment on the problems which followed in the ensuing period which, quite incidentally, might explain why the North East has not achieved the distinction in smoke control progress which has so deservedly been gained by progressive authorities such as Sheffield, Leicester and certain other provincial towns as well as many of the London Boroughs, all of which authorities have set examples of progressive action which could well be emulated by the more laggard authorities among us.

2. THE REGION

Although the Northern Division of our Society covers a region which includes the county of Cumbria, the generally accepted boundaries of North East England are those which applied to the former North East Division and now enclose the counties of Northumberland, Tyne & Wear, Durham and Cleveland and comprise 23 local authorities.

It is a region predominantly and traditionally industrial in character, despite the fact that therein lies, particularly to the north, areas of unsurpassed beauty of hill country, moorland and coastline, happily, as yet, unspoiled despite the activities of the local tourist board. The basic industries have for centuries been based on coal, shipbuilding and heavy engineering and, indeed, it can be said that it was on coal mining that the prosperity of the region, such as it is, has been built. It is in these industrial areas where the mass of the population lives, a population which has striven to wrest a living from a very unfavourable environment and in difficult circumstances, both economic and climatic; where unemployment has always been well above the national average; an area which is still striving to remove the "distressed area" stigma assigned to it half a century ago; a conurbation which, among other things, has sacrificed clean air in order to contribute much more than its fair share to the prosperity of the country by the industry of its population.

Industry, population and air pollution have been based on the three rivers, the Tyne, Wear and Tees, with the intervening land masses devoted to the production of coal and whilst this paper will relate to all of these areas so far as smoke control is concerned, because of my association and experience, the main

emphasis will be laid on the Tyneside situation with particular reference to Newcastle upon Tyne, the self styled regional capital.

3. IN THE BEGINNING

Whilst North East local authorities cannot be regarded as any less progressive in the field of social experiment and advancement than their counterparts elsewhere in the country, there have been, and still are, many local factors inimical to an innovation even so obviously worthwhile as domestic smoke control. In the early days the first obstacle was clearly apathy and, indeed, open hostility to the abandonment of coal as a domestic fuel, although this has been largely overcome. A brief examination of other adverse influences will do much to explain this initial apathy and hostility.

(a) Coal Mining

A very substantial proportion of the working population rely on coal as a means of livelihood and it is, therefore, not surprising that coal was naturally and traditionally regarded as the only acceptable fuel for all heating purposes. It has always been plentiful in the region and, until recently, comparatively cheap, and moreover for centuries it has formed a significant proportion of a miner's pay in the form of concessionary coal. It is, therefore, not surprising that in 1970 coal consumption per head of population in the Northern Region was fourteen times that in the London area, although the average smoke concentration was rather more than twice that in London.(i)

To persuade coal producers not to burn coal and to give preference to a "rival" fuel such as gas, electricity, oil or, indeed, any form of solid smokeless fuel is asking a lot of the mining community, a community which has suffered so much in the past, both from the economics of the mining industry and the hazards and difficult working conditions in ensuring the production of coal.

(b) Climate

Although meteorological authorities will tell us that the difference in the overall annual average temperature between the northern and southern counties of this country is a matter of only a degree or two, the storm lashed natives of the northern latitudes still look upon the south coast as being sub-tropical and the nearest approach to a Mediterranean environment that they are likely to experience in this country.

The difference in climate is reflected in the mode of living. It is rarely indeed that the weatherbeaten Northumbrian can enjoy meals alfresco as does his fortunate brother in the sunkissed south. The idea of living and dining outdoors in this way during the summer months is quite a fanciful notion to most Tynesiders (other than boy scouts and Army survival teams) and it is experienced only on rare occasions such as the summer of 1975.

It is, therefore, a climate which, to a material extent, accounts for the relatively high capital fuel consumption in the North East and which, taken together with the ready availability of coal, inhibits the aims of smoke control advocates.

(c) Economic Considerations

In common with certain other industrial conurbations, the North East has inherited unwanted legacies of the industrial revolution, all of which have from time to time made a heavy drain on the public purse. These legacies from a bygone age have created problems for hardpressed local authorities in this

region, problems which, with good reason, many of the inhabitants regard as having a higher priority on the public purse than smoke control. The clearance of the slums, the improvement of substandard houses, the progressive redevelopment of decaying residential areas, the renewal of obsolete town centres, the creation and restructuring of industry are all matters which loom in the forefront in assessing priorities - problems which were, and are still, perhaps more pressing in the Northern region than in many of the cities in the south.

Because of the economic implications of these social problems, the financial aspect of smoke control has had an inhibiting influence on progress. Arguments have been proffered submitting that if a major impact is to be made on domestic smoke abatement in as short a time as possible, immediate and major expenditure is inevitable and to do this the financing of smoke control from capital is to be preferred. This view is supported by the fact that as succeeding generations of ratepayers will gain the greatest benefit from clean air, it is only right that these same ratepayers should contribute their share to the overall cost of smoke control by undertaking the repayment of the loan charges. This persuasive argument is even more attractive when allied to the more recent demand that smoke control expenditure should be transferred from the locally determined sector to the key sector, but in many North Eastern authorities the economic demands of the overall situation leaves little, if any, margin available, whether it be from capital or revenue, locally determined or key sector.

(d) The Magnitude of the Task

Although, as already mentioned, the Northern Region includes Cumbria it was, in fact, only in the Tyneside, Wearside and Teesside areas that air pollution presented a truly formidable problem and today, although the position has vastly improved, the main incidence of such pollution is still confined to these industrial conurbations. It is therefore, not surprising that although death rates from bronchitis in England and Wales some 25 years ago were approximately twenty times those of Scandinavia,[ii] the incidence of this "English Disease" was even significantly higher in the North East region. As recently as 1972 deaths from bronchitis and emphysema were 56% and lung cancer 47% above the national average rates in Newcastle and smoke pollution, although not the only cause, had an undoubted influence on the high incidence of these conditions.[iii]

There is, therefore, reason to assume that the magnitude of the task of pursuing the abolition of smoke in the North East was somewhat more formidable than in many other of the "black" areas, particularly when it is noted that the 1961 annual average of smoke concentrations in the area now known as the County of Tyne and Wear exceeded 250 ug/m^3, with Newcastle having the dubious distinction of possessing the smokiest pollution survey site, a site which regularly produced figures of around 600 ug/m^3 as a mean winter concentration.

4. TRIALS AND TRIBULATIONS

Although, as everyone knows, it was the Act of 1956 which gave statutory powers on a national scale to proceed with the establishment of smoke control areas, certain steps had already been taken prior to that date in the North East, as elsewhere, to secure similar powers by promoting local legislation. These progressive attempts to deal with the problem were, however, overtaken by events in Parliament, although in Newcastle action was already in progress to formulate a smoke control programme before the Act of 1956 became operative. This resulted in the declaration of the first Smoke Control Area in the region - a rather modest affair of 118 acres in extent comprising some 1,500 premises in the central area of Newcastle, the order for which came into operation on the 1st April 1959.

At that time, and aided by supporting press and radio publicity, very considerable public interest was aroused and, in an endeavour to sustain this interest, the Newcastle City Council in 1958 promoted a Clean Air Exhibition of dimensions previously unkown in the region, the success of which enterprise was assured by the attendance on the opening day of the late Sir Hugh Beaver, K.B.E. who, at that time was the President of our Society.

In due course and largely as a result of the Ministry of Housing and Local Government Circular 5/59, many local authorities for the first time gave serious attention to the smoke control question. Nevertheless, considerable apathy still existed throughout the region as, in response to that Circular, only 11 of the 24 "black area" authorities in the region submitted programmes and fixed target dates for their completion. Later, after the publication of Circular 4/62, a further additional 6 authorities submitted programmes increasing the total to 17. Many of the target dates in these programmes were clearly over optimistic and some totally unrealistic but, nevertheless, the important feature to emerge from this undertaking was the fact that commitments to the cause of smoke control were made for the first time.

In Newcastle the target date for the completion of a programme to cover the whole of the city was fixed at 1975 and, in the conditions existing at that time, that date was regarded with confidence as being capable of being achieved. Had the curtain of the immediate future been lifted at that time, this confidence would have been seen to be unjustified.

(a) Fuel Supply Problems

During the first few years of activity in the North East the formulation of smoke control programmes was based on the replacement of coal burning firegates by improved open grates capable of burning soft coke (Gloco). This policy had the advantages of (a) the style of home heating by an open fire remained substantially the same, and (b) conversions and replacements were relatively inexpensive.

Local authorities, encouraged by repeated assurances of the continued availability of soft coke supplies, proceeded apace with their programmes and, indeed, Newcastle was considerably ahead of the national rate of progress in the creation of smoke control areas when, in 1963, a bombshell was dropped by the Minister of Housing and Local Government by the publication of Circular 69/63 which referred to a drastic change in the nature of solid fuel supplies.

Because of technological changes in the gas making industry the anticipated expansion in the supply of Gloco would not, in fact, take place to meet the needs of future smoke control areas and, in future, all such proposed areas would have to be based on the use of an alternative fuel, mainly hard coke (Sunbrite) produced by the National Coal Board. This development resulted in a very substantial increase in the cost of establishing smoke control areas in the Northern Region arising from the shortage of open fire solid smokeless fuel caused, in my opinion, by the complete lack of an effective national fuel policy. Because of the consequent need to convert open fires to enable hard coke to be burned, the cost of both the appliance and its installation was much greater than previously and local authorities were faced with the inescapable fact that the cost involved in establishing smoke control areas on a hard coke basis (as compared with the soft coke previously used) had increased threefold.

It was in 1963 that an Opinion Survey of 1,000 houses was carried out in Newcastle and it was a matter for congratulation to find that more than 95% of householders declared themselves in favour of smoke control with only 4% either non-committal or in opposition. It was clear that persistence and determination over the years were succeeding in changing the public attitude to smoke control,

but it was difficult, if not impossible, to maintain this favourable public support when the effects of Circular 69/63 became evident.

(b) The Suspension and Revocation of Orders

All local authorities throughout the North East region were now confronted with a situation to which there seemed to be no solution and smoke control as an effective continuing policy was brought to an abrupt halt as a result of Circular 69/63. Until mid 1963 those local authorities in the region with declared programmes had made reasonably good progress, albeit some 25% short of their declared objectives, but the effect of the abandonment of soft coke was that many of these authorities sought to withdraw or revoke orders which had previously been submitted and were awaiting confirmation. In all, 17 orders were affected in this way, comprising 14 in the Tyne & Wear Districts and 3 on Teesside. Of the 17 orders, 3 were revoked, 7 withdrawn and 7 held in abeyance to be subject to further review when the situation seemed more favourable.

An enquiry into the regional situation which I carried out in early 1964 revealed that not one of the 17 "black area" authorities with declared programmes intended to adhere to their programme. In 9 cases programmes were suspended and in the remaining 8 authorities programmes were drastically modified to enable smoke control to continue, but at a very much reduced rate. The confusion which thus descended on the region was reflected in the attitude of one large county borough whose spokesman expressed the opinion that recent events had made it very doubtful if smoke control would every become an accomplished fact, at least in that particular district.

Because of the increased cost of establishing smoke control areas, all completion target dates were either amended or abandoned, but even worse was yet to come. Those areas which had been brought into operation before the publication of Circular 69/63 had been based on the use of soft coke as a fuel, but despite an emphatic official assurance that "sufficient supplies of smokeless solid fuels for use in improved open grates would continue to be available to meet the needs of those living in areas already subject to smoke control",[iv] considerable anxiety continued to be felt for the future in these existing areas. Such anxiety was shown to be fully justified when, in February 1970, the Northern Gas Board informed local authorities in the region that the production of Gloco was to cease in March of that year, except for a small amount from the Stockton plant.

(c) The Gloco Disaster

The problems encompassing local authorities caused by increased expenditure and the consequent slowing down of future programmes of smoke control became overshadowed by the precarious situation in which existing smoke control areas were now placed. In Newcastle alone, the first eight orders of the programme, all of which came into operation before the end of 1963 and covered some 10,000 houses, were virtually left without soft coke supplies and it was necessary immediately to proceed with the making of a Suspension Order, the effect of which was to permit householders in those areas to burn ordinary coal instead of smokeless fuel and to permit fuel merchants to deliver coal in the areas without contravening the provisions of the Clean Air Act 1968. The Clean Air (Suspension of Smoke Control - City and County of Newcastle upon Tyne) Order 1970 was to operate for one year when, it was hoped, the fuel situation might be resolved.

Among those authorities which had lagged in the matter of smoke control were some who derived a perverted satisfaction from the embarrassment and discomforture inflicted on the advocates of clean air. Indeed, it seemed that those authorities who readily and vigorously undertook the task of pursuing smoke control in response to previous exhortations of the Ministry of Housing and

Local Government were now paying a grievous price for the outstanding ineptitude demonstrated by the chaotic state of fuel supplies and the lack of a practical fuel policy during the years immediately preceding these unhappy events.

It was, therefore, not surprising at this stage in September 1970 the Northern region maintained its lowly position in the Regional Clean Air League table with less than 30% of the "black area" premises under smoke control compared with more than 80% in Greater London. It was because of this spectacular lack of progress, largely attributable to the events outlined above, that an Investigation Panel of the Clean Air Council was appointed in February 1972, a body which included representatives of those North Eastern local authorities under investigation, charged with the task of "examining the progress of domestic smoke control in the "black areas" of the Northern Region, to suggest improvements as far as practicable, and to advise the Clean Air Council upon further steps which should be taken to this end".

(d) The North East under Investigation

The investigation, conducted under the chairmanship of Alderman Mrs. P. Sheard, C.B.E., B.A., J.P., of Sheffield, was determined and searching in its examination and the report presented in November 1972 included several far reaching recommendations. Amongst these was the recommendation that four named authorities should be formally consulted by the Secretary of State, in which connection the report referred to Section 8 of the Clean Air Act 1968 which empowers the Secretary of State, where he is satisfied that it is necessary in any particular area, and after consultation with the local authority concerned, to direct that a smoke control programme shall be prepared and thereafter implemented within an agreed period.[v]

It was, however, clear that the mere setting up of the Panel and its conduct of the investigation, aroused considerable local interest and had already stimulated activity before the publication of the report which also emphasised that the preparation throughout the region of complete smoke control programmes, carried out with consistency and speed, was vital to the future prosperity of the area, otherwise the Northern Region would, in the near future, earn for itself the title, "The Region with the Dirtiest Air in all England".

This resurgence of activity in the North East, undoubtedly activated by the Investigation Panel, resulted in the Northern Region climbing up the Clean Air Regional League Table until, in June 1973, the West Midlands and the South West were left below them - a very modest beginning, but in the right direction.

Perhaps one of the more important developments to emerge from the recommendation of the Panel was the establishment of the Joint Clean Air Committee for the North East, a body which was established under the chairmanship of Councillor Mrs. J.M. Scott-Batey, Chairman of the Health and Environment Committee of the Newcastle upon Tyne City Council.

(e) Governmental Discouragement

This new found energy and activity in the North East in the matter of smoke control was, however, short lived and although the castigations of 1972 may well have been merited, it was difficult to understand the absurdity of the situation created by the publication by the Department of the Environment very soon thereafter of Circulars 171/74 (Rate Fund Expenditure 1975/76) and 88/75 (Local Authority Expenditure in 1976/77 - Forward Planning).

Circular 171/74 included the advice in para. 39 that "The Government accept that for the year ahead local authorities may not be able to undertake any more development in the field of smoke control." If any laggard North Eastern local

authority required an excuse for continued inactivity, surely here it was on an official basis and the various interpretations and misinterpretations of this enigmatic paragraph created great concern in the North East.

Protestations by the Northern Division of the Society produced a reply that "Paragraph 39 of the Circular was in no way intended as an absolute prohibition. The paragraph was so worded that those local authorities who wished to continue their smoke control programmes and who could justify such action, could submit proposals to the Department of the Environment. The Clean Air Council were assured that the D.O.E. would deal reasonably with any programmes so submitted."

It was not surprising that this meaningless reply was met with dissatisfaction by the Northern Division and further representations were made to the Clean Air Council with the support of the North Eastern Planning Council and the Northern Group of Labour Members of Parliament.

Even worse was yet to come. In Circular 88/75 (Local Authority Expenditure in 1976/77 - Forward Planning) an even stronger line of action was indicated in para. 21 which stated that "Anti-pollution (e.g. clean air) measures may need to be curtailed..." Again the Northern Division of the Society discussed the matter and considered that this para. 21 of Circular 88/75 was even more damaging to the clean air cause in the North Eastern Region and deplored this restriction on activities to abate pollution in an area noted for its high incidence of chronic bronchitis and urged the Secretary of State for the Environment to treat the North Eastern Region as a special area or, in any event, to give an expression of encouragement to local authorities in this polluted region not to slacken efforts in their present smoke control programme.

5. THE CURRENT SITUATION

Despite the many problems and uncertainties to which reference has been made above all is not, however total gloom in the North East. Although there still is too great an element of tardiness on the part of many councils to pursue smoke control, the overall position has improved greatly over the years, as indicated in the following table.

Year	% Premises in Region Subject to Smoke Control Orders
1968	16
1969	18
1970	19
1971	24
1972	33
1973	35
1974	38
1975	39
1976	39

Within the area to which the above figures relate, Middlesbrough deservedly enjoys the well merited distinction of leading with more than 89% coverage, although eight other districts (out of a total of twenty-three) have yet to commence smoke control.

Perhaps the development which affords greatest satisfaction is the remarkable improvement in the air quality of the Tyneside conurbation which is illustrated by the reduction in pollution concentrations in the four districts comprising this conurbation.

Year	Local Authority							
	Gateshead		Newcastle		N. Tyneside		S. Tyneside	
	Smoke ugm/m3	SO_2 ugm/m3	Smoke ugm/m3	SO_2 ugm/m3	Smoke ugm/m3	SO_2 ugm/m3	Smoke ugm/m3	SO_2 ugm/m3
1961	251	217	226	202	226	119	298	159
1962	132	103	226	204	204	137	269	193
1963	125	132	202	174	209	115	249	184
1964	97	71	226	166	206	120	221	188
1965	122	105	216	168	168	132	202	143
1966	127	137	154	146	152	114	186	160
1967	259	86	112	152	151	114	167	138
1968	123	105	124	138	127	107	155	167
1969	104	94	133	169	133	110	176	164
1970	102	88	144	162	95	106	132	111
1971	72	71	111	139	109	115	106	85
1972	70	72	104	132	82	107	82	84
1973	59	57	96	147	73	66	93	120
1974	35	51	60	87	44	56	68	97
1975	44	51	46	91	50	55	51	90

Gratifying though the progress indicated by the above figures might be, it must not be thought that the whole of the reduction in levels of pollution is to be attributed to the effect of smoke control on domestic pollution. The smoke control orders apply equally, of course, to all classes of premises and the contribution to smoke abatement by industrial and commercial interests has been significant, a view which is supported by the fact that in the areas of the districts in question, the levels of SO_2 concentrations have not fallen with the same proportion

Despite the problems of the past, a positive attitude to smoke control is being fostered among North Eastern local authorities, an example of which is the fact that one particular district which has hitherto displayed a conspicuous lack of interest, earlier this year embarked upon a phased smoke control programme. Moreover, and despite governmental gloom spread by Circular 45/76[vi] all authorities are either proceeding apace with their published programmes, or are at least maintaining a level of token progress, no matter how slow, so that there will still be a degree of continuity in smoke control activity when in the early 1980's this country will enter the promised land and speedily complete and pay for all remaining smoke control work from the fruits of North Sea oil.

Until then, however, local authorities must continue to cope with the intractable and frustrating problems arising from an outstanding inability to manage successfully our national and local government financial affairs and continue to hope that some day there will be devised and declared a comprehensive national fuel policy which takes into account air pollution considerations. But these aspects could well form the subject of a separate paper.

REFERENCES

(i) National Survey of Air Pollution 1961-71, Volume 1, Table 2.2

(ii) Committee on Air Pollution Report 1954, Page 8.

(iii) Newcastle upon Tyne statement of evidence to Clean Air Investigation Panel 1972.

(iv) Ministry of Housing and Local Government Circular 69/63, Para. 7.

(v) Clean Air Council - Domestic Smoke Control in the North East. Report by a Panel of the Council. (Paras. 50-53 and 76)

(vi) Joint Departmental Circular (DOE) 45/76 - Local Authority Expenditure 1976-77.

43rd ANNUAL CONFERENCE

EDINBURGH

11th - 15th October, 1976

THE FINDINGS AND RECOMMENDATIONS OF THE ROYAL COMMISSION ON ENVIRONMENTAL POLLUTION

by

Sir Brian Flowers, FRS

National Society for Clean Air,
136 North Street,
Brighton BN1 1RG.

In June 1974 the Royal Commission on Environmental Pollution, of which Sir Brian Flowers, FRS was at that time Chairman, were invited to undertake a study with the following terms of reference: 'To review the efficacy of the methods of control of air pollution from domestic and industrial sources, to consider the relationship between the relevant authorities and to make recommendations'.

At the request of the Secretary of State, the Royal Commission invited six people, nominated by him and having special knowledge of the problems involved, to be associated with the Commission for the review. The Commission were asked to report quickly, if possible within a year, and in the event, their Fifth Report entitled 'Air Pollution Control: An Integrated Approach' was published in January 1976.

In the course of their enquiries, the Royal Commission received oral and written evidence from a vast number of people and organisations, amongst them, the National Society for Clean Air. Local Authorities and industry were visited in all parts of the country. In all, the Royal Commission made no less than ninety four recommendations which range from those concerned with domestic smoke control, the best practicable means and air quality guidelines, through enforcement, registration and consents to planning, and last, but by no means least, the establishing of a unified pollution inspectorate dealing with the control of all forms of pollution - air, water and land.

Sir Brian Flowers, who was the Chairman of the Royal Commission at the time when the enquiries were carried out and the Report was prepared and published, will present the salient features of the Report for discussion.

After Sir Brian has made his presentation, Mr. W.F. Lester, the Director of Scientific Services of the Severn Trent Water Authority will reply giving the views of the water authorities with particular reference to the establishing of the unified pollution inspectorate which would be responsible for controlling pollution of water as well as air and land.

43rd ANNUAL CONFERENCE

EDINBURGH

11th - 15th October, 1976

PEOPLE, POLLUTION AND RETRIBUTION

by

Professor G. Melvyn Howe, DSc.
University of Strathclyde

National Society for Clean Air
136 North Street
Brighton BN1 1RG

"The hope that disease can be completely eradicated becomes a dangerous mirage only when its unattainable character is forgotten. It can then be compared to a will-o-the-wisp luring its followers into the swamps of unreality. In particular it encourages the illusion that man can control his responses to stimuli and can make adjustments to new ways of life without having to pay for these adaptive changes. The less pleasant reality is that in an ever-changing world each period and each type of civilization will continue to have its burden of diseases created by unavoidable factors of adaptation to the new environment." (Dubos, 1965)

Up to the nineteenth century Britain had its burden of communicable diseases. Until that time, water supplies were inadequate in both quality and quantity, water disposal systems were poor or non-existent, insect and animal reservoirs and vectors (carriers) of disease agents were abundant, and health education was insufficient - to which was often added the resistance-sapping factor of malnutrition. Later, largely as a result of the efforts of Edwin Chadwick improved sanitary water supply and waste disposal diminished the faecally-related diseases and better housing and less crowding reduced the air-borne diseases. Sanitation also contributed to reductions in another group of diseases - the vector borne diseases - by destroying breeding and feeding areas for insects and small animals. Our debt to Edwin Chadwick ('Father of the Sanitary Idea'), Southward Smith, Neil Arnott, J. P. Kay, John Snow and John Simon for promoting sanitary reform is incalculable. The burden of communicable disease was lifted through enlightened environmental changes, improved nutrition, education and therapeutic advances. Deaths from communicable diseases fell and lifespan increased. (Table 1).

Period	Male				Female			
	England & Wales	London	Scotland	Glasgow	England & Wales	London	Scotland	Glasgow
1841	40.2	35.0			42.2	38.0		
1871-80			41.0	30.9			43.8	40.2
1881-90			43.9	35.2			46.3	44.3
1911-12	51.1	49.5			55.0	54.5		
1920-2	55.6	55.3	53.1	48.4	59.6	60.0	56.4	50.8
1930-2	58.7	59.5	56.0	51.3	62.9	64.4	59.5	55.2
1950-2	66.4	67.3	64.4	62.0	71.5	73.0	68.7	66.3
1960-2	68.1		66.2		74.0		71.9	
Early 1970's	69.0		67.5		75.0		73.5	

Table 1. Expectation of life in years at birth in different parts of Britain (in part from D. V. Glass, 1964).

But, as Dubos states, complete eradication of disease is unattainable; each period continues to carry its 'burden of diseases'. Instead of communicable diseases, twentieth century Britain is plagued by the degenerative diseases of middle or later life (cardiovascular diseases and cancer) and accidents (mainly traffic accidents) in young adults and children. These are generally multifactorial in character and have in common the fact that medical prevention is still in its infancy.

The adverse environmental factors or stimuli which give rise to maladjustment or disease (i.e. the 'unavoidable factors of adaptation to the new environment') relate in the main to pollution or degradation associated with the atmosphere, water supply, food, land and soil, housing, occupation, etc., in each case the response being conditioned by the genetic make-up (i.e. internal environment or inborn constitution) of the individual.

Relationships between external environmental factors and health are extremely complex and there is still a great deal of uncertainty on many issues. In this brief review, a few severely selected components of the total environment will be considered separately, though it should be stressed that in practice they constitute an inseparable whole.

Atmosphere

Almost all studies have confirmed the adverse effects of atmospheric pollution upon human health. Three dramatic and well-documented episodes in this century - in the Meuse Valley in Belgium in 1930, in Donora, Pennsylvania, U.S.A. in 1948 and London 1952 - demonstrated that, in extreme cases, community

air pollution can result in considerable loss of life and serious illness. Death and distress on each of these occasions was due largely to bronchitis and other diseases involving impairment of respiratory function. There was also a rise in the number of deaths due to heart disease, resulting possibly from the additional strain placed on the heart by impairment of respiratory function or to a more direct effect. Evenso the exact nature and extent of the associations between atmospheric pollution and community health are still not fully established; even the damage mechanisms are not completely understood. It has proved difficult to assess exactly how many of the 'excess deaths' which followed these pollution episodes should have been strictly attributable to air pollution since many of the casualties were either very old or were otherwise particularly susceptible to air pollution.

Factors which may affect the sensitivity of people to air pollution include age, sex, general state of health and nutrition, concurrent exposures, pre-existing disease, and air temperatures and humidity at the time of exposure. In general, older persons, the very young, those in poor health, cigarette smokers, the occupationally exposed, and those with pre-existing chronic bronchitis, ischaemic heart disease and asthma, are the more vulnerable to pollutant exposures.

Lave and Seskin (1970) have questioned the value of the 'episodic relationships' found by correlating daily or weekly mortality rates with indices of air pollution during short-term acute pollution episodes. They have argued that air pollution is a subtle irritant and that it is unlikely that a healthy person will succumb to a modest rise in pollution levels. Perhaps interest should be focussed upon the initial cause of illness rather than on the factor that is the immediate determinant of death. It is possible that short term exposure to large doses of pollution may be less damaging to most people than exposure to lower concentrations for long periods of time.

Figure 1 shows the spatial variability of male deaths (ages 15-64 years) from lung-bronchus cancer in England and Wales for the period 1970-72.[1]

Because of the excess occurrence of the disease in urban areas, the Royal College of Physicians of London (1970) examined the possibility of air pollution being a causal factor in cancer of the lung. Their conclusion was that the evidence <u>against</u> the importance of community air pollution as a causal factor in lung cancer was stronger than the evidence for it.

Epidemiologists have demonstrated a clear quantitative relationship between the incidence of lung cancer and the

---

1. Standardised mortality ratios (SMR) - which allow for peculiarities in the age structure of local populations - are plotted on both geographical and demographic base maps. In the case of geographical base maps prominence is given to the mortality experience of extensive, unevenly populated areas at the expense of limited and localised areas of dense population associated with, say, the county boroughs. An incorrect impression of regional intensities of mortality experience may thus be created. The demographic base map relates mortality ratios to the local populations at risk.

number of cigarettes smoked. This risk factor is enhanced by habits which, like inhalation, increase organ exposure to smoke. On present evidence the cigarette - 'the most lethal instrument devised by man for peaceful use' - is the major risk factor in lung cancer.

The foregoing effects of air pollution on human health refer to such common urban air pollutants as sulphur dioxide and suspended particulate matter (dust, grit, smoke[1]), and to some extent to carbon monoxide and 'oxidants'. There are, however, many other chemical pollutants occurring in urban air, particularly in the vicinity of specific industries ('the effluent of affluence'). These include lead, mercury, cadmium, beryllium, manganese, fluorides, asbestos and airborne organochlorine pesticides. There is at present little or no epidemiological evidence as to the effects of such pollutants on community health; what information that is available relates solely to populations in the neighbourhood of pollution sources. However, the pollutants in question are known to be harmful to health, either on the basis of occupational exposure studies or of animal experiments, usually conducted at much higher concentration levels than those normally found in community air.

Moulds, dusts and vegetable fibres are among the wide range of airborne materials which pollute the atmosphere and are capable of eliciting a hypersensitive (allergic) response in susceptible individuals.

It seems reasonable to assume that mental well-being may be adversely affected by such phenomena as impaired visibility, loss of sunlight and smoke-stained buildings and fabrics following pollution of the atmosphere.

Water

Human health may be affected by the drinking of water contaminated by pathogenic bacteria, viruses, parasites, and other organisms. The pollutants may include the faecal and urinary excretions of man and animals, sewage and sewage effluents, and washings from the soil. Typhoid fever, paratyphoid fever, gastroenteritis and bacillary dysentery are among the principal diseases attributable to the ingestion of water-borne bacteria. Cholera and infantile diarrhoea, due to pathogenic bacteria transmitted by water, were not uncommon in nineteenth century Britain. (Fig. 2).

With the ever increasing use of beaches for recreational purposes, and the dangers associated with the consumption of marine fish and shellfish from polluted waters it is understandable that increasing attention is being devoted to coastal pollution. However, on a large scale survey of 40 or more bathing beaches around the English coast known to be

---

1. It must be acknowledged that there has been a marked decrease in the amount of smoke pollution in the United Kingdom through the Clean Air Acts and the progressive growth of smoke control areas or smokeless zones: emissions of sulphur dioxide show only a relatively small decrease.

contaminated with sewage, only four cases of paratyphoid fever were recorded as having been due, probably, to bathing.

Reports from several countries have shown an inverse statistical association between hardness[1] of drinking water and the death rate from cardiovascular disease. Areas supplied with soft drinking water almost consistently experience a significantly higher prevalance of either ischaemic heart disease or degenerative heart disease, hypertension, sudden deaths of cardiovascular origin, or a combination of these. Nevertheless, in the case of the City of Glasgow, supplied throughout with soft drinking water from Loch Katrine, several of its 37 wards have a favourable mortality experience from ischaemic heart disease with standardised mortality ratios well below the U.K. average. (Fig. 3).

Food

Food can serve as a vehicle for the distribution of two major groups of organisms pathogenic to man. There are those associated with endogenous animal infections which are transmissible to man, and those micro-organisms from the environment that contaminate food. The diseases caused by microbial contaminants of foods include salmonellosis (infective gastroenteritis, typhoid and paratyphoid fever), shigellosis (bacillary dysentery), trichinosis, taeniasis and amoebic dysentery.

Chemical contamination of food has recently become a cause for concern. Chemicals such as lead, cadmium and mercury which can enter the human environment from a variety of sources including mining and metallurgy, chemical industries, scrap metal treatment, electroplating, superphosphate fertilizers, weed killers, fungicides, sheep dips, lead smelting, production of storage batteries, manufacture of alkyl lead and lead paints, paper and pulp, plastics industries, etc., and affect health through the food chain. Adverse health effects include loss of appetite and weight, diarrhoea alternating with constipation, gastrointestinal disturbance, conjunctivitis, and the formation of kidney stones. Chemical food poisoning is likely to occur when unsuitable containers are used for the storage or cooking of foods.

Land

Pollution of the land by toxic chemicals (nitrates, phosphates, etc.) from agriculture (e.g. fertilisers, pesticides) and industry, leading to the contamination of soil, food and water, may prove to be a significant hazard to health. It is known for instance that excesses of mercury, lead, cadmium or selenium, whether eaten in vegetable matter or animal foods, can seriously affect man's health. Deficiencies of trace elements

---

1. In most cases the hardness (pollution?) is due to the content of calcium and magnesium (and sometimes aluminium and iron).

such as copper, iron, manganese, zinc, iodine, fluorine, cobalt and molybdenum give rise to nutritional problems.

Housing

There is still uncertainty regarding the influence of poor housing on health. Associations between overcrowding and tuberculosis and infant mortality, rheumatic heart disease, common respiratory diseases, etc. have been examined but the results are conflicting. It has often been stated that faulty design and construction of houses may help to produce mental unrest and thus exacerbate mental disorders already afflicting the occupants; that sensory annoyance and dis-satisfaction may make an important contribution to mental unrest, that noise and unpleasant smells lead to nervous irritability and bad temper. The effects of rehousing on health have been considered in several studies but the findings to date are conflicting.

In addition to the conventional accidental injuries in the home, modern technology has introduced a variety of consumer products that present new chemical, electrical, mechanical and radiation hazards. One side of the problem is the potential of these products for traumatic injury; the other aspect, on which practically no information is available, is the possible deleterious effects of long term, low level exposure.

Occupation

Occupational hazards are often encountered in industry, agriculture, mining and other working environments. Exposure to dusts can lead to a wide variety of respiratory diseases, including pulmonary fibrosis, obstructive lung disease, allergy and lung cancer. Toxic dusts may produce systematic poisoning after inhalation or act as skin irritants to produce dermatosis, allergic reactions and cancer.

Occupational exposure to quartz dust can cause silicosis; asbestos fibres can cause fibrosis of the lung (asbestosis), mesothelioma and lung cancer. Solvent vapours may be toxic. Occupational exposure to ultraviolet radiation (mainly in arc welding) mainly affects the eyes, causing intense conjunctivitis and 'welder's flash'.

The increasing generation of nuclear power in fission reactors is a cause for deep concern since it cannot be guaranteed to be an entirely safe process. Nuclear incidents in reactor plants have occurred and some of these have resulted in the escape of radioactive materials. Radiation in certain cases may result in cancer and in other cases the mutation of genetic cells and therefore, in the longer term, the birth of damaged infants. The storage of radioactive waste presents additional problems. (Fig. 4).

Noise

The effects of transport, construction and industry noise on man are varied and indefinite. Physical illness brought about by noise appears to be limited to damage to hearing, although sudden and unfamiliar noises can cause stress and even fear. Noise can also cause feelings of annoyance and irritation. A study of admissions to a psychiatric hospital has shown a correlation between ambient noise level and admission rates of certain categories of mental illness. Strangely enough teenage pop fans at discos exposed to noise levels far in excess of recommended industrial levels rarely exhibit hearing loss.

A recent meeting of the Institute of Biology heard evidence which indicated that diseases caused by noise among people in urban areas ranged from tumours of the brain to sickness. The groups of people affected were those particularly sensitive to low frequency vibrations. This issue is worse in modern towns and cities because new types of buildings provide an amplifier for the noises to do 'intolerable harm'. Seemingly a single, very low frequency vibration, of 38 cycles a second, tends to dominate and is picked up by most modern buildings.

Modern Urban Environments

The urban environments of today differ markedly from those to which man has been exposed throughout much of his evolutionary experience. Despite man's physiological and behavioural adaptability it has been argued that signs of maladjustment or maladaptation would be expected in these historically, new situations. Certainly the urban way of life must make its own particular biological and psychological demands on the individual and the community. These would include reversible adaptive changes, physiological and behavioural, together with irreversible developmental adaptability.

The general view appears to be that associated with modern living in general, and particularly in urban situations, there are components of the environment and many aspects of the activity imposed upon individuals that are stressful. To define 'stress' is difficult but it may be recognised as compromising factors which act to disturb homeostasis, impose a load on adaptable mechanisms and likely to be manifest chronically, if not acutely, in a reduction in fitness. Stresses occur in all environments but because the contemporary urban environment is so new and so different from that which prevailed throughout most of human evolution it is likely to impose high levels of stress. The consequences of such stress may be expected at every level of biological organisation, physiological, biochemical and psychological. The tempo and tensions of life in the large modern urban communities of the developed world are such as to lead to stress, believed by many physicians to be a factor in mental illness, ischaemic heart disease and stroke.

Comment

The environment is under constant interference by man. Some of the changes being wrought are imperceptible and insidious, others are blatantly obvious. What is beyond doubt is that man is altering the balance of a relatively stable system - the ecosystem - by his actions. The ecology of life in this country and on this planet Earth is being radically changed by man's actions. From the health point of view some of the changes may be good, some may be harmful and others may prove catastrophic. That there are, at present, no precise views of the impact or effects of the changes being brought about in the balance of the natural forces and of the new environment being created by man is cause for serious concern. It would seem palpably unwise to continue to interfere with the natural environment without, at the same time, striving to determine the real and lasting effects of such actions on man's health and general well-being. To ignore these effects is to court disaster, indeed it might well lead to the death of tomorrow.

BIBLIOGRAPHY

Boyd, J. T. Climate, air pollution and mortality. Brit. J. Prev. Soc. Med., 14, 123-35 (1960).

Chadwick, E. Report on the Sanitary Condition of the Labouring Population of Great Britain, 1842. Edited, and with an Introduction, by M. W. Flinn (Edinburgh, 1965).

Dubos, R. Man Adapting. New Haven (1965).

Glass, D. V. Some indicators of differences between urban and rural mortality in England and Wales and Scotland. Public Health and Urban Growth, Centre for Urban Studies, University College of London, Report No. 4. London (1964).

Heimann, H. The status or air pollution health research. Arch. Env. Health, 14, 488-503 (1967).

Howe, G. M. The geographical distribution of cancer mortality in Wales, 1947-1953. Trans. Inst. Brit. Geogs. 28, 190-215 (1960).

A national atlas of disease mortality in the United Kingdom. London (1970).

The geography of lung-bronchus and stomach cancer in the United Kingdom. Scot. Geog. Mag. 87, 202-220 (1971).

Man, environment and disease: a medical geography through the ages. New York and London (1972), Harmondsworth (1976).

Environmental factors in disease. In Health and the Environment (Eds.) J. Lenihan and W. W. Fletcher, Glasgow and London (1976).

Lave, L. B. & Seskin, E.P. Air pollution and human health. Science, 169, 723-33. (1970).

Lawther, P. J. Air pollution and its effects on man. In Pollution Abatement (Clayton, K. M. and Chilver, R. C. Editors). Newton Abbot (1973).

McCarroll Measurements of morbidity and mortality related to air pollution. J. Air Pollution Control Assoc. 17, 203-9. (1967).

McDermott, W. Air pollution and public health. Sci. Amer. 205, 49-58. (1961).

Marsh, A. The December smog: a first survey. J. Air Pollution Control Ass. 13, 384-7. (1963).

Ministry of Health (UK) Mortality and morbidity during the London fog of December 1952. Reports on Public Health and Related Subjects, 95, London (1964).

Schrenk, H. H. et al. Air pollution in Donora, Pennsylvania: epidemiology of the unusual smog episode of October 1948. U.S. Pub. Health Bull. 306. (1949).

Speizer, F.E. An epidemiological appraisal of the effects of ambient air on health: particulates and oxides of sulphur. J. Air Pollution Control Assoc. 19, 647-55. (1969).

Wise, W. Killer Smog. New York (1970).

World Health Organisation Health hazards of the human environment. Geneva (1972).

TRACHEA, BRONCHUS, AND LUNG CANCER

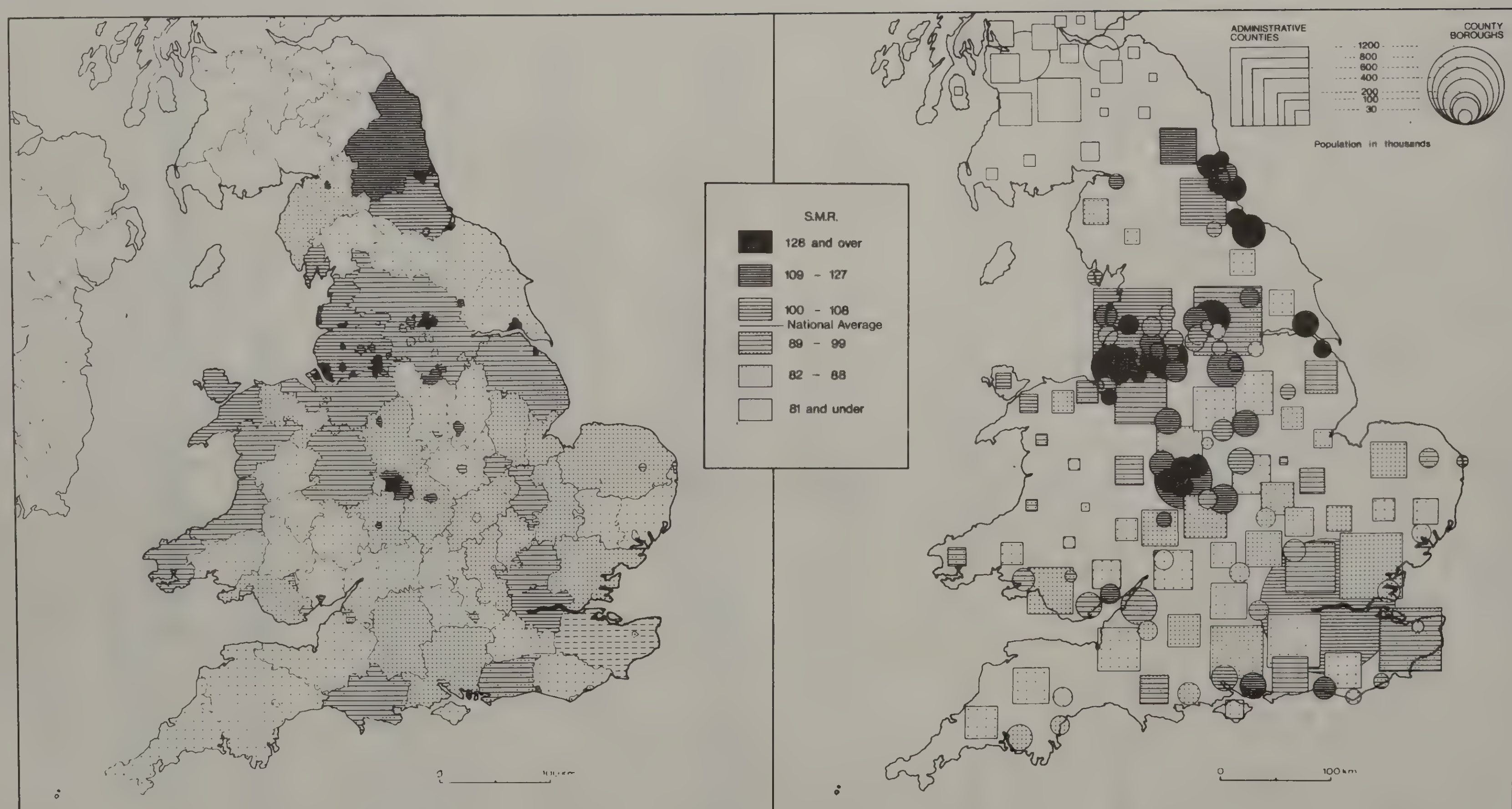


Fig.1 Spatial variability of male deaths (ages 15–64 years) from lung-bronchus cancer in England and Wales, 1970–72, based on data kindly provided by the Registrar General, London.

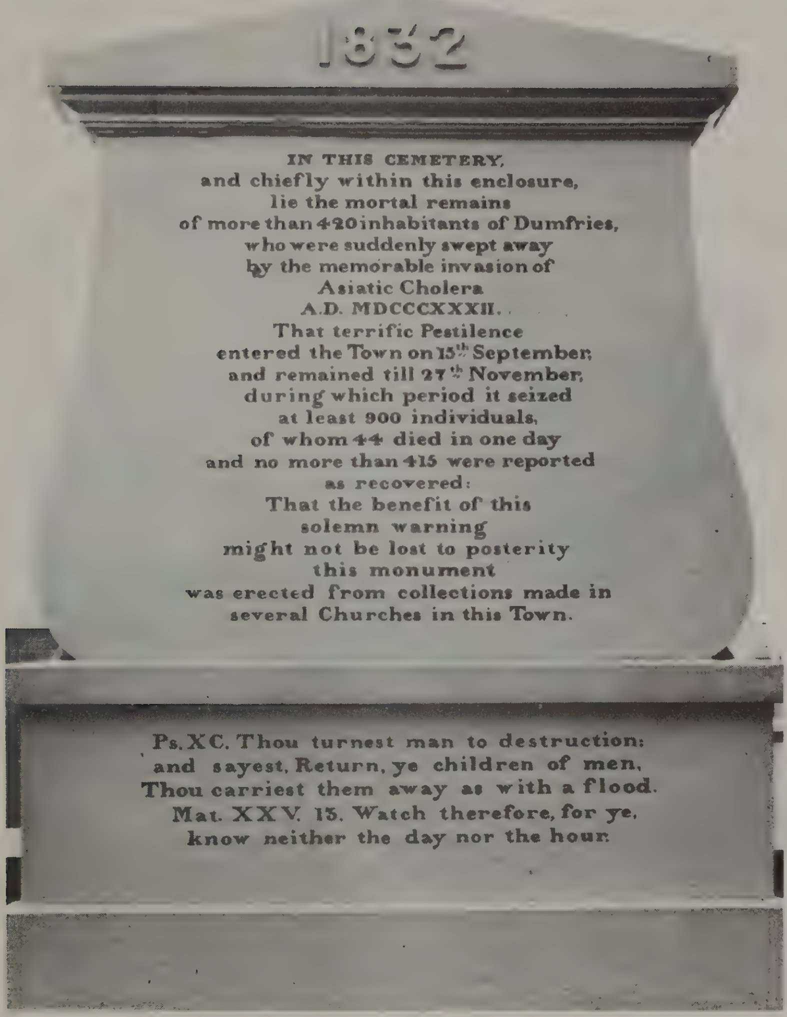


Fig.2 Tombstone in St. Michael's Kirkyard, Dumfries, to 420 victims of cholera in 1832.

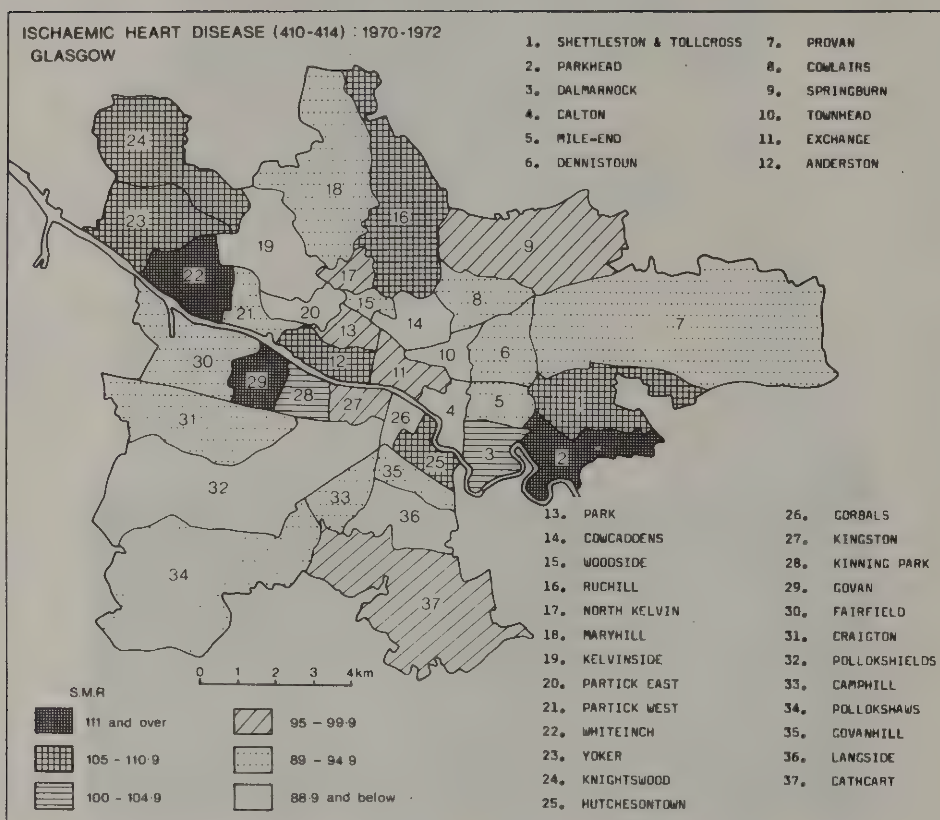


Fig.3 Spatial variability of ischaemic heart disease in Glasgow.

Now, that's what I call built-in obsolescence

Fig.4 The hazard of radio-active pollution.
(New Scientist)

43rd ANNUAL CONFERENCE

EDINBURGH

11th - 15th October, 1976

RURAL POLLUTION - THE HIGH PEAK, DERBYSHIRE
(with particular reference to stone quarrying)

by

I. Holmes, D.M.A., M.E.H.A.,
Area Environmental Health Officer
Borough of High Peak

National Society for Clean Air
136 North Street
Brighton BN1 1RG

GENERAL INTRODUCTION

The Borough of High Peak came into being on the 1st April, 1974 and comprises an amalgamation of the Boroughs of Buxton and Glossop, the Urban Districts of New Mills and Whaley Bridge and the Rural Districts of Chapel-en-le-Frith and Tintwistle.

It is situated in the north west of the County of Derbyshire and the boundaries of the Boroughs directly abut Greater Manchester and the Counties of Yorkshire, Staffordshire and Cheshire. It has a total area of 133,629 acres, some 93% of the area being within the Peak District National Park, and a population of approximately 80,000.

The Borough forms a substantial part of the Peak District which because of its natural beauty was the first area in the country to be designated a National Park. High Peak includes the Hope and Edale valleys, the beautiful Derbyshire Dales of Chee Dale and Wye Dale and the Snake Pass, as well as the rugged grandeur of Kinder Scout. Tourism is certainly one of the major industries and is regarded with importance by the Borough Council.

The prosperity of the Borough hinges jointly on tourism and the industries which in certain cases often appear incompatible especially to the visitor to the area.

The greatest concentrations of population lie in a corridor outside the Peak Park situated on the western side of the Borough, which is interspersed with large tracts of farmland. It is a major recreation area for the conurbations of Greater Manchester and South Yorkshire.

Within the Borough there are many industries including major quarries, many light manufacturing industries, a number of chemical works and other industries including iron and steel, cement, expanded foams and plastics, a major asbestos works and various brick making concerns, including twenty three scheduled processes under the Alkali Acts. The land used for farming is predominantly pasture and grassland, the area being classified as either Grade 4 or Grade 5 by the Ministry of Agricutlure, Fisheries and Food in its Agricultural Land Classification. Grade 4 land is defined as "land with severe limitations due to adverse soil relief or climate or a combination of both." Grade 4 land is generally only suitable for low output enterprises and is normally under grass with occasional fields of oats or forage crops. Grade 5 land is that of the lowest agricultural quality.

THE EFFECT OF LOCAL GOVERNMENT RE-ORGANISATION

Local Government re-organisation considerably affected the attitude of the local authority towards pollution control when compared to that of the former authorities responsible for this function.

The High Peak Council through its environmental health department commissioned the production of a Policy Statement. The Policy Statement was produced following meetings with other departments of the local authority and a preliminary survey of the area to determine the extent of the problems. These in conjunction with detailed analysis of the volumetric results and the complaints received in the past made up a part of the report from which the Policy Statement was drafted, together with details of the past policies adopted by the former authorities and the progress they had made in the pollution control field.

This report clearly defined the air pollution problems in the High Peak and it was found practicable to list the different categories and place them in an order of priority even though the classifications must be somewhat arbitrary and control of the various forms go on concurrently.

The order of these priorities was as follows:-

(i) Domestic smoke.
(ii) Industrial smoke.
(iii) Grit and Dust.
(iv) Low level smoke from the burning of waste materials in the open.
(v) Sulphur Dioxide at breathing level.
(vi) Vehicle smoke and fumes.
(vii) Odour.
(viii) Toxic and other gases.

In some cases, for example a particular emission of toxic material, an incident might of course get very rapidly promoted and it may be necessary to follow Matthew Ch.20 V. 16 and adopt a policy of 'the last shall be first and the first last.'

The report also discussed noise in detail, together with the financial implications of any policy adopted by the authority. The result of the report to the Health Committee after much discussion by them was a Policy Statement regarding the future policy to be adopted by the Council towards the control of both air pollution and noise in the High Peak.

THE ENVIRONMENTAL HEALTH DEPARTMENT - of the Borough operates from three separate area offices, each area being autonomous and controlled by an area officer directly responsible to the director of environmental health. There is no specialisation in the department, except that each area officer co-ordinates at least two major functions and several minor functions of the department. The purpose of this part-time co-ordination role being imposed on each of the three area officers enables uniformity of standards throughout the area to be achieved, facilitates smooth operation and continuity in the absence of the director, and makes sound management sense to an authority committed to corporate management with the resultant multiplicity of inter-departmental meetings.

The Council is conscious of the changing patterns of pollution, and is convinced that in order to ensure efficient control it is necessary to keep under constant review the department structure and establishment responsible for its pollution control function.

THE PROBLEMS:

1. THE QUARRIES

The diversion of responsibility for environmental control between H.M. Alkali and Clean Air Inspectorate and the Environmental Health Officers of the Borough Council is itemised in Appendix 1, and the results of their joint actions are described below.

The High Peak contains fourteen quarries, winning gritstone, sand, shale, basalt and limestone; most win limestone. The quarries range from the very small to what is believed to be the largest limestone quarry in Western Europe.

This part of Derbyshire has an extremely long history of involvement in the minerals industry. The ancient mineral industries of the County were, for many years, associated with the extraction of lead and it is reported that lead was worked in the Peak District back to Roman times. Barytes and fluorspar were also mined.

In more modern days the principal mineral worked in the area has been limestone and the area around Buxton is historically the centre of the lime burning industry in the county since concentrations of both coal and limestone are readily available in close proximity to each other.

From the end of the Nineteenth Century the greatly increased demand for limestone to serve the alkali industry, and for use as road aggregate greatly increased the number of quarries.

Approximately 2,000 persons are directly employed in the quarries, and many others in the area rely indirectly upon the industry to provide them with a living. These include haulage contractors, and those engaged in the manufacture and maintenance of quarry plant and equipment. Not only is quarrying one of the Borough's principal industries, but also one of the principal ratepayers, having a rateable value of almost £750,000 being almost one tenth of the total rateable value of the Borough. It is estimated that around 10 million tons of stone were produced in 1974.

During the past few years to ownership of the quarries has passed out of the hands of small operators in to the arms of large industrial concerns. This trend has caused some rationalisation of the industry. Several quarries have closed whilst others have expanded with consequential increase in output. This change brought pollution problems particularly of dust due to the more intensive use of older equipment and the problems associated with the development of new equipment. Most of the problems have now been identified and steps are being taken to reduce dust, noise and smoke emissions.

In 1971 the control of certain processes became registrable under the Alkali Acts. Previously only lime burning using coal or oil were registrable. (See Appendix 1 for brief summary of various processes involved.)

The problems dealt with in relation to quarries are those of noise, dust and smoke.

1A. NOISE: The three main sources of noise from quarries are:-

(i) Blasting.
(ii) Quarry vehicles and mobile machinery.
(iii) Fixed plant and installations.

(i) Blasting - The public complain about both noise and vibration which are generally attributable to primary and secondary rock breakage by blasting. The actual procedure of rock blasting involves a series of steps in preparing the blast and following the explosive's detonation, each of which has its influence on noise and vibration.

Quarries are usually worked on a relatively high face and require, after blasting a properly contoured pile of rock at the bottom of the face in pieces of a size that can be easily handled by the loading, haulage and crushing plants.

It is important to differentiate between vibration caused by sound, and that caused by ground movement. When explosives are fired within rock, as in a primary blast, some of the energy shatters the rock, some is transmitted as ground vibration, and a small fraction is transmitted as airborne sound. Conversely, when an explosive is fired in air, as in a quarry face dressing, almost all of the energy is transmitted as airborne sound. Therefore, a face dressing shot, consisting of, say 5 lb. of explosive produces higher sound levels than does a primary blast. Conversely a face dressing shot produces virtually no ground vibration in contrast to a primary blast. A significant part of the sound produced by a primary blast arises from the explosive cord used to initiate the blast - this is often referred to as "air crack".

Some interesting developments are taking place within the quarrying industry to reduce the environmental impact of blasting; they can be summarised as:-

(a) A reduction in height from 200 feet to 60 feet of quarry faces enables a man to be lowered on a rope to prise loose rocks from the face which may constitute a danger to men working below. This practice reduces the number of face dressing shots fired, and consequently instances of vibration and noise from airborne sound are considerably reduced.

(b) Popping (the breaking of large rocks on the quarry floor by use of explosives) has been replaced by mechanical drop ball techniques resulting in a very significant improvement to the noise and vibration climate of the area.

(c) The development of new explosive cords such as is expected to considerably reduce the "air crack" from this operation. Experiments have been made with trunk detonating cords by covering them with quarry fines, however, if a sharp air crack is to be avoided they must be covered to a depth of 9". Noise levels measured 20 feet from the detonating fuse line at right angles to propagation direction are summarised below:

Open detonation	95 dBA
Uniform covering to a depth of 3"	95 dBA
Uniform covering to a depth of 6"	92 dBA
Uniform covering to a depth of 9"	85 dBA

It must be noted that some quarry shot firers refuse to cover the trunk detonating cords as they have a fear of premature explosion. Where the problem is acute milli-second delay detonators can be used to initiate downhole lines, but extreme care is required if the higher numbers are used, as the longer delay period between successive hole detonations may cause a cut-off. In practice a delay time of seventeen milli-seconds between downhole detonations is found to approximate the ideal.

Physiological effects of Blasting - One of the most difficult stages in carrying out an investigation into complaints from blasting is the assessment of nuisance. When complaints are made to the local authority, the Environmental Health Department are usually called upon to investigate them.

It must be emphasized that the rating of vibrations and noise and their effect on people at their home is wholly subjective, rarely does one encounter levels sufficient to cause physiological damage. The most relevant work to date concerning the subjective reaction to impulsive sounds is that of Rylander, Sorenson et al on Sonic Boom Exposure Effects on Human and Animals, and suggests that there is little correlation between boom levels and the annoyance experienced by the individual, but correlation is observed between the number of people annoyed and both boom level and the number of booms. In other words, if the boom level or number of booms increase, the number of people dissatisfied with their environment would also increase but the level of dissatisfaction expressed by the individual would not necessarily change.

(ii) Quarry Vehicles and Mobile Plant - there are three main sources to consider - drilling, overburden removal and clearing stone, each of these sources can be considered in terms of B.S.4142 "Method of Rating Industrial Noise Affecting Mixed Residential and Industrial Areas."

The quarries are forever looking to the future and in the main they have adopted a policy of "purchasing with quietness in mind". For example one quarry has recently carried out sound level measurements on a rotary drill and its associated compressor which have shown an improvment of 10 dBA less than the present primary drills.

As the quarries develop areas closer to residential development then research and development of a new generation of quieter machines will most certainly

have to follow if "noise creep" is to be avoided and existing background levels pegged.

The problem of transporting the finished product from the quarries by either rail or road causes localised problems, in the form of convoys of heavy goods vehicles passing through small towns and villages. Noise levels in excess of 100 dBA have been measured in the normally quiet streets of villages.

The strategy of both the Planning Authority and the Highways Authority in consultation with the industry has been the provision of selected routes for quarry traffic, and other roads in the area are subject to Weight Restriction orders.

(iii) Static Plant - Noise levels from the static plant such as kilns and crushers can be dealt with by using B.S.4142. However forward planning by the quarry companies in relation to the siting of such items as close to the quarry floors as possible has reduced noise considerably.

Specially designed silencers for the large high speed fans on lime kilns have been successfully developed; for example complaints of pure tone noise nuisance were received over an area 8 miles from a quarry and a purpose built resonator was fitted to the tops of the chimneys. These noise problems can be particularly complex to abate.

1B. DUST: The rationalisation of the industry into the control of large companies caused in the short term an increase in the dust burden from point sources, due to the greater use of the often outdated capital equipment on the site. However, in the long term the amount of dust emitted must fall due to the greater resources of the companies operating the quarries to invest in the provision of pollution control equipment.

If dust deposition is taken as the dust which falls at a particular point, this can be collected over a period and weighed to calculate the dust deposition rate. It is extremely difficult if not impossible to identify the source of dust collected at a particular point, due to the number of quarries in the area, and the background dust deposited from distant sources.

The dust emitted from fixed plant such as lime kilns is calculated by measuring the quantity of gas passing up the stack, and the dust burden per unit volume. Dust from operations such as vehicle movement on dusty roads cannot easily be measured.

Grit and Dust emissions fall into two main categories:-

(i) Fixed Plant - production processes
(ii) Quarrying Operations.

(i) Fixed Plant emissions are easily measured and these problems reduced by selecting a dust collection technique from the many available (See Appendix 2). It has been estimated for one quarry producing approximately 6 million tonnes of limestone per annum that without controlled dust collection some 300 tonnes of dust would be emitted per day; by 1970 this figure was reduced to 48 tonnes emitted per day and by capital expenditure and other action it has progressively reduced its daily emission to 21 tonnes despite increased output.

(ii) In the quarry, dust is generated from four main sources:-

(a) The drilling process, prior to blasting
(b) The actual primary blast
(c) Vehicle movements on quarry roads
(d) Wind whip - quarry surface

(a) The vertical drill holes fill up with dust as the drill rotates and are blown clear using compressed air; airborne dust from these drills was approximately 2.25 tonnes per day. By 1973 improved dust arrestment techniques had reduced this amount to 0.25 tonnes per day. During 1975 a quarrying company experimented with an improved method of collector and reduced the amount on one drill to 0.03 tonnes per day and by 1980 it is expected that emissions from drills will not exceed this figure.

(b) The amount of dust generated by the primary blast is difficult to measure, owing to its transient nature. Attempts have been made to measure the quantity of dust 400 to 1000 yards away. For an output of 6 million tonnes/annum of stone it has been estimated 0.1 tonnes/day of dust will travel in excess of 400 yards in the worst case assuming that on no occasion would dust be suppressed by rain.

(c)(d) In work carried out at one of the quarries in the High Peak it was estimated in 1975 (a dry year with 39 inches of rainfall compared with an average of 50.5 inches over the previous 20 years) that on a dry dusty day 10 tonnes per day of dust could be raised by vehicles and wind whip if the roads were not treated.

In an attempt to overcome this problem quarry roads are bound with waste sump oil. Experiments are in progress at another quarry using calcium chloride which is hygroscopic. Using these suppression methods it is possible to reduce the dust raised to 3 tonnes per day.

The following table of dust emissions from one major quarry summarises the improvements in relation to the suppression of dust and predicts trends to 1980.

Average Dust Emission Rates (Tonne/day)

Source of Emission	Without Dust Collection	1970	1971	1972	1973	1974	1975	1980 (Est.)
Major Plant	300	48	36	33	34	26	21	11
Quarrying Activities	10	10	8	6	3	2	2	1
Total	310	58	44	39	37	28	23	12

When reading the above figures it must be remembered the figures for 1970 relate to 6 million tonnes of stone quarried whilst the later figures for the 1980's are for 10 million tonnes per annum.

1C. SMOKE: The largest volumes of smoke generated by the quarries are undoubtedly due to the use of coal fired lime kilns which under certain firing conditions produce vast quantities of dense black smoke. The coal fired vertical shaft kilns receive a fresh charge of coal hourly; for the first twenty minutes volatiles are distilled from the coal in the absence of sufficient air for complete combustion. The intractability of this problem led to the kilns being scheduled under the Alkali Acts, and by 1958 the technique of "cutting the smoke at the stack" by admitting air to burn the volatiles was developed, this reduced smoke emissions and by the 1960's many shaft kilns had been fitted with this device.

During the 1960's oil became a primary fuel in shaft kilns and reduced the density of the smoke emitted, however it caused a continuous emission of less dense smoke.

In 1972/73 natural gas became available and a shaft kiln was experimentally converted to this fuel, and it was found that smoke emissions were eliminated and emissions of grit and dust were considerably reduced.

Development of rotary hearth kilns such as the "calcimatic" (which produces lime more expensively) and the conversion of all shaft kilns to gas firing will, it is hoped, by 1980 reduce smoke to acceptable levels.

10. WASTE: The wastes from the quarries and quarry processes have to be disposed of in disused parts of the quarry for economic reasons and problems have been created. It is disheartening to any of the pollution control agencies to see expensive gas cleaning equipment installed and the fine dust particles that are removed from them by tanker, discharged on a tip and then blown over a wide area by wind whip. There is a market for some dusts, and some recycling is practised through rotary hearth cement kilns. However large volumes are still tipped.

Experiments are being undertaken by universities and the quarries in attempts to grass over quarry tips and some success has been obtained in growing trees on reclaimed land, but that work is outside the scope of this paper.

PUBLIC PARTICIPATION AND THE DISSEMINATION OF INFORMATION

The Council is anxious to keep the people informed of all matters of public concern. Because of prolonged nuisance conditions prevailing at Earl Sterndale and Sterndale Moor, the Council was instrumental in the formation of Hindlow Local Liaison Committee. The Committee is comprised of Councillors from High Peak, West Derbyshire, Hartington Middle Quarter Parish and Hartington Upper Quarter Parish as well as members of the public, two Alkali Inspectors and Environmental Health Officers from West Derbyshire and High Peak.

The benefits of this Committee are beginning to be appreciated and include:-

(1) A platform for discussion of problems by the Public, Technical Officers and Quarry Management.
(2) Setting of Objectives by discussion and co-ordination of monitoring techniques.
(3) Dissemination of unbiased information.

An immediate benefit has been the siting of 13 Deposit Guages by the four Quarries and the two Local Authorities so as to encircle comprehensively the total quarrying area. These guages will show both trends and patterns of dust deposition. Co-ordination of the results is being undertaken by the Health Department.

The Health Department of the Borough Council because of its availability to Members of the Public receives not only complaints of atmospheric pollution from installations controlled by Statutes it enforces, but also complaints relating to processes scheduled under the Alkali etc. Works Regulations Act, 1906. The complaints are made to one of three offices of the Health Department that is, at Glossop, New Mills or Buxton. When complaints are received of registered processes, observations are made and preliminary investigations made where appropriate. The District Alkali Inspector for the area (one of two operating within the Borough) is notified, and follows up the notification with an inspection of the works in question.

2. OTHER INDUSTRY

The High Peak contains a mixture of other industrial processes and each has a pollution potential and requires control. The Environmental Health Officers co-operate freely with H.M. Alkali and Clean Air Inspectorate in the control of registered processes in the area, and frequent meetings between the two agencies take place.

For example - Di-isocyanate Works - a registered process in accordance with the Alkali Acts. The area has four works in close proximity to one another and though they are not the subject of complaint from the general public, they do cause some interesting problems. The area is regarded as one of scenic beauty and the works were established some time ago in valley bottoms. During the past twelve months the alkali inspectorate requested the expanded foam industry to raise the height of their process ventilation ducts to keep ground level concentrations to a minimum. In the case of one of the works in our area it meant raising the ventilators from 30 feet above ground level to some 130 feet and it does not require much imagination to conceive the public outcry to such a scheme.

However (applying the "wisdom of Solomon") a solution to the problem of visual amenity was found. The planning consent was granted on a temporary basis for a period of ten years, so that if and when technology produces a more efficient method of treating the effluent gases from the process, then the fume duct can be reduced in height and used in conjunction with the new gas cleaning process, before a further planning consent will be granted.

There are many other processes too numerous to mention in a paper of this size, however, it may be interesting to make mention of the following:-

(i) The area contains many old mills which are being converted for use by other industries, consequently the banks of Lancashire Boilers are removed and replaced by one package boiler for heating purposes only.

The department has adopted a policy of persuading the new owner to connect his boiler to the existing stone or brick chimney (which is much higher than could be required for a new chimney) and also to fix to the top of the stack an inverted cone to increase the efflux velocity of the exit gases. A multiplicity of new shiny metal stacks is thus avoided and the area maintains its visual character.

(ii) Recently a number of companies have taken to burning waste in small incinerators connected to these large stacks, and the department has once again adopted a firm policy of warning and prosecution of offenders and attempts are made to find alternative methods of refuse disposal. The poor standards of operation and maintenance of small incinerators has led us to the conclusion that a multiplicity of such equipment must be avoided.

(iii) Many of our problems are the result of poor planning decisions in the past and many dirty processes became established in the area possibly caused partly by the inability of those concerned in decision making to appreciate the effect of the processes applied for, and partly by the view that "if it pays rates let it in".

The authority now controls its own planning function and the mistakes of the past will not be repeated in the future.

2A. PLANNING: The department responsible for planning matters automatically consults all other departments of the authority on every planning application. This authority is committed to corporate management and any department can report

to the Planning Committee, though in practice this is done through the Planning Department. The practice of consultation extends throughout the whole of the planning function. The structure and forward plans are discussed at inter-departmental meetings. Development control and planning enforcement are used as much on the recommendation of the environmental health department as that of planning. It is not uncommon to find joint actions against companies taking place concurrently by both environmental and planning departments. In the field of public inquiries for refusal of planning permission the two departments provide a united front to resist development which is considered unsuitable.

The major environmental problems of the borough can be related in many cases to bad planning decisions of the former planning authority. It is only since 1974 that a systematic attempt has been made to create separate areas of industry and housing.

Many new housing developments have been constructed in areas of open countryside due to the controlled expansion of some of the villages which in itself has caused many problems.

The people buying the properties have frequently been attracted from the towns of the large conurbations to live in the countryside, and many intractable problems have developed. The town "immigrants" may well like to see animals such as pigs and cows but they do not like to smell them. Many of our problems are caused at this interface between extown turned country dweller and the established country industries. For example manure spreading and stubble burning cause numbers of complaints out of all proportion to the nuisance experienced.

The establishment of many riding stables (which serve vast population areas) in and around the new housing developments also produce a regular crop of complaints.

The psychological or psychosomatic problems caused by certain semi-country industries are unbelievable if not experienced at first hand. An example of this is a large maggot breeder who decided to establish his business in one of the smaller villages which has a fair proportion of ex-town dwellers. As he constructed his buildings and they began to near completion, but before the process of maggot breeding actually began, complaints of "pungent odours in the night" which made many of the villagers "vomit" began to be received by the department. On investigation it was found the process had not even started and the impossible task of explaining to the complainants began. However, the maggot breeder decided for reasons of his own to move to a different part of the district which is more remote and offered better facilities for his work. Unfortunately all is not well; one of a small group of cottages passed into the hands of an ex-town dweller who had retired to the country and the complaints began to come in. The cottages are over a mile away from the farm and odour nuisance has to date not been detected despite response to many complaints from the one source.

2B. PUBLIC PARTICIPATION - the authority in the planning field embarked on a scheme of public participation and two "ad hoc" committees comprising three residents, the chairmen of the planning and health committees, officer representatives of the health and planning departments, and members of the respective companies were established to consider planning applications for extensions to two companies in sensitive areas. The results were excellent after many meetings, and the suspicions and fears of the public were considerably reduced once a dialogue between the respective parties had been established.

The opening of lines of communication between industry and the public we believe is the key factor in harmonizing relations between areas of mixed residential and industrial development. The success of the first two local liaison committees

resulted in the "ad hoc" committees recommending to the planning committee that the plans for industrial expansion should receive favourable consideration.

The response by industry to these committees has enabled environmental works such as landscaping to be carried out by them to a far higher standard than the local authority could insist upon.

The logical extension of these "ad hoc" committees which focus on "a particular factory" or "area" is the establishment of a Pollution Prevention Panel. The department have followed with interest the pioneering work of authorities such as Coventry in this field, and our authority is working along the lines to establishing such a panel. In the meantime we are providing a limited industrial service:-

Industrial Service: The environmental health department will survey any industrial premises in the area on request and provide an Environmental Appraisal of the location covering air pollution, noise and refuse disposal and suggest areas which require improvement. However, we do realise our limitations and we do not attempt to replace the professional consultant; we limit ourselves to providing factual information of the conditions before and after, the standards required in law, and suggested areas requiring improvement. It is hoped that we will be able to extend our noise measuring service into the factory itself and recharge for the work carried out.

Monitoring: The Council co-operate in the National Survey of Smoke and Sulphur Dioxide and have also monitored lead deposits in the area. Their work of monitoring will be extended to asbestos very shortly, and consideration is to be given to a survey of heavy metals in the atmosphere.

In the field of noise control a limited amount of work has been carried out monitoring sound levels throughout the area with a view to producing some form of noise contour map; however this work is still in its infancy.

Dust deposits are monitored at several scattered sites around the quarries as part of a joint exercise between the quarrying industry and the local authorities.

CONCLUSIONS

1) In an area which relies heavily on tourism for its prosperity the impact of industry has to be very carefully balanced to avoid a conflict of interest at the interface between tourism and industry.

2) There is no room for complacency, the effort to reduce all forms of pollution must continue, in particular the domestic smoke control programme must be continued at its present rate of progress despite financial restriction.

3) Consultation between other pollution control agencies and those of the Borough Council should be encouraged, as an essential precursor to the development of a total pollution control concept. Pollution comes in a variety of forms from a multiplicity of sources and the remedies necessary cover a wide range of activities. Pollution in one form can almost invariably give rise to pollution in other form and whilst the control measures are different they sometimes overlap. Accordingly, the control of pollution can never be simple nor can any one form of pollution be dealt with entirely in isolation.

4) Real environmental improvement will not be achieved by the use of palliatives to current problems, but rather by determining an ultimate goal for the development of the harmonious interaction of all social, spatial and economic activities within society.

A vision of what is valuable and possible needs to be defined and our apparent success in dealing with what appear to be current problems should only be recognised in relation to that ultimate goal.

ACKNOWLEDGEMENT

I wish to acknowledge the expert advice provided by Mr. R.V. Tomlinson, Director of Environmental Health, The Borough of High Peak and the help of my colleagues in the Northern Area Office of our Department.

I am grateful to the Borough Council for allowing me to present this Paper. The views and opinions expressed are those of the Author and not necessarily those of the Council. An expression of appreciation must be made to I.C.I. Ltd., for providing many of the slides used to illustrate the Paper.

VARIOUS PROCESSES INVOLVED IN QUARRYING LIMESTONE

	Control Authority	Potential * Nuisance
1. The Quarrying of the Stone		
Removal of overburden	Borough Council	Dust
Drilling of rock face	Borough Council	Noise-Vibration
Primary Blasting	Borough Council	
Secondary Blasting (almost now replaced by drop-ball technique)	Borough Council	Noise-Vibration
2. The Crushing of the Stone		
Transfer of stone from Quarry face to Primary Crusher by lorry	Borough Council	Dust-Noise
Primary Crushing - various types of crusher normally no nuisance	Alkali Insp.	
Secondary and Tertiary Crushing	Alkali Insp.	Dust
3. The Processing of the Stone		
a) Graded Stone (Aggregates)		
Screening	Alkali Insp.	Dust-Noise
Grinding of Limestone	Alkali Insp.	Dust-Noise
b) Coated Roadstone		
Stone is dried and mixed with bitumen	Alkali Insp.	Dust
c) Lime Burning		
Lime burned in coal or oil fired kilns	Alkali Insp.	Smoke-Dust
Lime burned in gas fired kilns	Borough Council	Dust
d) Lime Grinding	Borough Council	Dust
e) Lime Hydration		
Lime (CaO) slaked with water to form Calcium Hydroxide $Ca(OH)_2$	Borough Council	Dust
f) Cement Manufacture		
Limestone and shale mixed, milled, burned and ground	Alkali Insp.	Dust-Fumes
4. Dispatch of Products		
Vehicle Loading	Alkali Insp.	Dust
Disposal of Waste including dust, slurry, unburnt or partially burnt lime.	Council Council	Dust

* The control of Noise and Vibration in all cases is the responsibility of the Borough Council.

There are five separate and distinct categories of gas cleaning and dust collecting equipment commercially available each with its specific range of applications.

1. Gravitational - Settling Chambers
2. Inertial - Cyclones
3. Filtrational - Bag Filters
4. Scrubbing - Gas washers & venturi's
5. Electro Static Precipitation†

The approximate minimum particle size of which the various gas cleaning types are suitable are listed below. As there are a great number of special types of collectors, the classification must necessarily be broadly interpreted.

Seperator Type		Minimum Particle Size Microns
Gravity		200
Centrifugal Cyclones	Large Diameter	40-60
	Small Diameter	20-30
Filter		0.5
Scrubber	Low Energy	2-5
	High Energy	0.01-1.0
Electro Static		0.001-1.0

Many factors influence the ultimate selection of dust collection equipment, such as particle size, temperature, volume, moisture content, performance required, and grading and burden of dust at arrestor inlet.

It is now generally accepted that the exponential growth of energy consumption which has been experienced for many years in various countries in the world cannot continue indefinitely and that we must shift the emphasis in our use of energy from the 'more is better' attitude to 'enough is best'. The conventional fossil fuel sources of energy have limited finite lives and by the end of this century the North Sea Oil and Gas Industry will be declining very rapidly. The three papers presented under this heading will review the major alternative, non-polluting sources of energy, but wind, tidal and geothermal sources will also be covered.

The primary flow of energy giving life comes from the sun, and many of our additional requirements stem from a need to supplement its light and heat when and where there is least of it. We start with a fundamental mis-match between our energy demands and the supplies which we can obtain from the sun. Vast quantities of solar energy are available but of low intensity and very variable when most needed. The intensity of radiation at the outside of the earth's atmosphere is 1.35 kW/m^2. By the time this radiation has reached the earth and been scattered by dust and water vapour the maximum intensity is perhaps 1 kW/m^2. Averaged over a whole year, in the United Kingdom, the intensity works out at about 105 W/m^2, although at the peak period of the year from May through to September, the average daily solar radiation experienced in the UK is about as good as anywhere else in the world. The present world's annual energy consumption is in the order of less than one tenth of one per cent of the actual amount of energy which the world receives from the sun.

Considerable advances have been made in the applications of solar energy both for domestic water heating and space heating applications. It must be appreciated that it is difficult to apply solar energy for space heating to an existing building and a buidling has really to be designed with the utilisation of solar energy in mind from its initial conception. Solar cooling is unlikely to have any applications in the United Kingdom but has considerable export potential. Solar power applications are being studied extensively in the United States and Japan. The concept of a power tower will be presented. Small scale solar pumps have been built on many occasions and there are two particularly interesting UK developments in this field - one developed by the UK AEA at Harwell and the other at the University of Bristol. For direct electrical generation, large sums of money are being spent on research and whereas at present it would take £20,000 for an array of solar cells which could produce, at best, 1 kilowatt, this is a factor of at least ten less than it would have cost some ten years ago, and it is hoped that further research will reduce this by a further factor of about 100 over the next 25 to 30 years.

Wind cannot be called a new source of energy since it has been used for many centuries, but practical designs ranging from between 100 watts and about 2 megawatts are perfectly practical by today's standards. Scotland has a particularly favourable wind climate since the strongest winds occur in winter, particularly off the western coast and in the western isles and wind power can be harnessed directly to provide heat when the demand is greatest. A recent study on the wind climate at Tiree - a small island off the west coast of Scotland - showed that a district heating wind unit of 18 m diameter would produce nearly 500,000 kilowatt hours of electricity per annum together with nearly 200,000 kilowatt hours of hot water and that the pay-back period for these units would be less than three years at current UK oil prices. Based on electricity prices in Tiree, the pay-back period would be about two years.

Several reviews of overall alternative energy sources have been published recently. Four of these are as follows:-

(1) Nature, 249, No. 5459, June 21st 1974. Special energy review series.

(2) Science, 184, No. 4134, April 19th 1974. Issue devoted to energy.

(3) National Geographical Magazine, Volume 148, No. 12, December, 1975 for article on wind. Volume 149, No. 3, March 1976 for article on solar energy.

(4) The Times, March 26th, 1976 - special report on energy.

43rd ANNUAL CONFERENCE

EDINBURGH

11th - 15th October, 1976

THE DISPOSAL OF TOXIC AND RADIO-ACTIVE WASTES

by

Dr. D.H. Sharp

The Society of Chemical Industry

National Society for Clean Air,
136 North Street,
Brighton BN1 1RG

The disposal of toxic and radioactive waste is a very vast subject and would indeed warrant a conference - and indeed has warranted several conferences - of its own. However, I propose to outline problems that may be set the local authority and others in complying with the provisions of the relevant Act[1] (Control of Pollution Act 1974), hereinafter called the "Act", insofar as the disposal of toxic wastes is concerned. Insofar as radioactive wastes are concerned it will be my intention to outline the problem and the solutions that are being applied and projected, and to put the matter in perspective.

Part I Toxic Waste

Probably the first study in depth of the problems associated with the disposal of toxic wastes was carried out by a committee under the Chairmanship of Dr. A. Key, and hereinafter referred to as "the Key Committee". The Key Committee was appointed in July 1964 by the Minister of Housing and Local Government and the Secretary of State for Scotland and consisted of 21 persons drawn from Government departments, manufacturing industry, local authorities, and the waste disposal contractors. It met on 20 occasions and received evidence from 38 organisations directly as well as a substantial amount of information from a large number of local and river authorities. Its report[2] entitled Disposal of Solid Toxic Wastes was published in March 1970. At the time it is fair to say that the report did not receive the attention that it deserved but it is also true to say that the Act embodies most of the recommendations and distilled wisdom contained in the report. In particular the report drew attention to the reluctance of local authorities - the very understandable reluctance - to make provision for the receipt and treatment of toxic wastes and called for "the provision of better facilities for proper and safe disposal". The Committee also considered that the (then) "present legislation on toxic solid wastes is (in) adequate". It was recommended that "the method and technique of disposal were specifically authorised by somebody with adequate technical and local knowledge" and that the authorising bodies should be the new local authorities. Many of the other recommendations of the Key Committee have been incorporated in the Act and it would indeed be fair to say that the Key Committee provided the background thinking on which the Act was based.

In dealing with the subject of the disposal of toxic waste it is important first to define our terms.

Accordingly I shall define "waste" as the solid or liquid material that it produced as an unwanted by-product in an industrial or manufacturing process and that is disposed of outside the curtilage of the factory concerned. This definition differs somewhat from that given in Section 30 of the Act which refers to "scrap material or .... effluent or other unwanted surplus substance". This (former) definition, implies that a waste is something that leaves the factory and requires some positive action on the part of someone to ensure that it is satisfactorily disposed of. Another implication in both definitions is that the waste is valueless and, indeed, insofar as it may well give rise to costs for its disposal, it has a negative value.

Perhaps surprisingly, the Key Committee found great difficulty in defining toxicity. The reasons are, however not far to seek. Toxicity is largely a matter of degree and of dosage not to mention the species involved. I think it would be generally agreed that in common parlance to call a substance or a waste, "toxic" implies:-

i) Ingestion by mammals or birds of relatively small quantities causes pain, distress or damage to health, whether permanent or temporary and whether immediate or delayed.

ii) The substance kills certain plants, notably trees.

iii) Some degree of persistence is usually implied - resistance to "weathering" (oxidation, hydrolysis, and volatilisation) and to attack by the natural organisms found in soil. To give some obvious examples, quicklime although certainly toxic would very rapidly weather to become slaked lime which would not be regarded as toxic; certain sulphides would certainly be regarded as toxic but on weathering become sulphates which can be quite innocuous.

iv) Solubility is implied. The problem here - and indeed a major problem to be resolved when resort is made to "tipping" is protection of water supplies, particularly underground water supplies. Thus solubility, particularly to water which perhaps has had its pH changed by percolation through surface layers, is an important factor.
It is clear that infectious substances must be included under (i). Perhaps the most obvious example of a toxic waste product which has been much in the news of late is asbestos due to the propensity to induce asbestosis.

It is interesting and significant that the Act does not refer to toxic wastes, subdividing wastes into "controlled" (which may include toxic wastes) and "special wastes, which may be "dangerous or intractable".

Most of the problems associated with the safe disposal of toxic waste are indicated by the definitions outlined above. Any treatment costs for safe disposal of toxic wastes are non-productive and therefore even the most responsible of manufacturers will always minimise the cost devoted to the disposal of waste material. Whereas the responsible manufacturer will segregate his wastes and not seek to "hide" some noxious substances with a mass of innocuous substances, the less responsible manufacturer will be inclined to do this. Similarly even the most responsible of waste disposal contractors will minimise costs as will the local authority in dealing with such materials - particularly in times as at present when there is great pressure to contain public expenditure.

The second point is that the toxic waste material can cover such a wide variety of substances that a good deal of expertise is required in order to devise sensible plans for disposal of such material, and expertise is expensive.

The third point perhaps to make is that in any human or industrial activity perfect safety is impossible of attainment. Mistakes will inevitably be made. There can be no absolute standard of safety; no industrial process can be carried on and no disposal of waste can be made without <u>some</u> disturbance to the environment. Someone, some body, or the body politic, must at some time make a subjective judgement of what is reasonable and what is safe. For this reason the words of the various alkali acts that "the best practicable means" shall be used to deal with a nuisance, in this case air pollution, are so approved of by industry. This phraseology does imply that there can be no perfection and that a subjective judgement must be made.

Furthermore, since it is always impossible to say with absolute certainty that no damage will arise, it is always very much easier as the Key Committee found out, for any authority to refuse to accept waste for disposal than to accept it. Section 9 of the Act requires the authority ...." to take the steps needed for the purpose of ensuring that the activities .... do not cause pollution of water or danger to public health or become seriously detrimental to the amenities of a locality affected by the activities ....". Thus while damage

to the amenities is accepted and is qualified that it shall not be "seriously detrimental" - which implies a subjective judgement being made by someone, pollution of water and danger to public health are absolute prohibitions. This absolute provision is of course impossible to comply with and was the very point - the very natural reluctance of local authorities to agree that sites could be used for tipping wastes - that led to the prevalent "fly" tipping which was very difficult to control.

This provision, evidently put in for political reasons to placate the environmental lobby is at variance with the recommendation of the Key Committee that the legislation should .... "give all parties sufficient freedom of manoeuvre so as to arrive at the optimum overall solution in a particular case without being inhibited by restrictions which, for that case, would hinder rather than help".

One must however, accept that the absolute requirements as laid down in the Act are not, in practice, absolute and where the Act says "do not cause pollution of water or danger to public health", in practice there will be considerable caveats and what will really happen, it is to be hoped, is that the interpretation of the requirement as regards pollution will be something like "the authority will satisfy itself that provided the regulations are properly applied and that the site selected for disposal is not disturbed and provided that a proper survey at the time indicates that pollution of water supplies to an unacceptable extent is not likely to arise, the local authority can be held to have carried out its statutory requirements". As regards danger to public health, something like: "provided that no hooligans, children, or stray animals, break down the fencing or otherwise trespass upon the area used for disposal, and provided that there are no cloudbursts, thunderstorms of unusual severity, tornadoes, whirlwinds or hurricanes, severe earth tremor or earthquake or other Acts of God, or crash landing of aircraft, there will be no unacceptable danger to public health".

Land Disposal

The Key Committee took pains to find out so far as it could how much toxic waste required to be disposed of and how it was disposed of at present. This information was gathered by the C.B.I. and was submitted to the Key Committee with several caveats about its accuracy and is reproduced at Table I. It will be seen that 201,677 tons of waste out of a total of 11,091,388 tons or 1.8% was described as "indisputably toxic". Of this 150,670 tons or nearly 75% was disposed of in surface tips. Admittedly this was the situation circa 1967 but there is little reason to doubt that the same situation obtains today. Thus of the methods available for disposal of toxic waste, surface tipping remains the most important - at least the most widely used.

The Key Committee took the view that if disposal on any particular site on land had been carried on for many years without obvious detriment to water supplies or to public health, it was reasonable to assume that disposal could continue at that site. The Key Committee also recommended the use of old mine workings and other underground cavities for the disposal of wastes, under suitable safeguards.

The Key Committee referred to the growth of expert firms dealing with waste disposal and of the formation of the National Association of Waste Disposal Contractors (N.A.W.D.C.), which was about to produce a code of practice for the safe operation of tips and the like.

In the event the N.A.W.D.C. approached the Institution of Chemical Engineers with a view to co-operation in producing an acceptable code of practice for the handling and disposal of toxic wastes. Uniquely the present author was a member both of the Key Committee and of the Working Party established jointly by the Institution of Chemical Engineers and the National Association of Waste Disposal Contractors. In November 1971 the Institution of Chemical Engineers received informal suggestions and encouragement from the Royal Commission on Environmental Pollution, as well as an approach by the N.A.W.D.C., that they would welcome a lead from the Institution for the provision of such a code of practice. The Working Party was set up in December 1971 and completed its task by 17th April 1972 under the Chairmanship of Dr. E.L. Streatfield, by publishing: A Provisional Code of Practice for Disposal of Wastes.[3]

The Streatfield Working Party took a less sanguine view than the Key Committee about land and disused mine workings for the disposal of toxic wastes but considered land disposal was safe provided that a geophysical and hydrological survey showed that percolation of the leachate (the liquor carrying dissolved solids) would be minimal.

The Working Party also recommended chemical treatment and incineration in suitable cases.

In sum, the essential elements involved in the safe and expeditious disposal of toxic wastes are:-

i) Elimination of reduction in quantity of toxic wastes during the manufacturing process.

ii) Having reduced the amount of toxic waste to be disposed of to segregate the wastes requiring special treatment.

iii) Having separated the wastes then carefully controlled transport to an appropriate site for disposal.

iv) Where appropriate, special treatment methods for intractable wastes such as simple chemical reaction including oxidation and hydrolysis, or incineration, particularly for organic wastes.

v) If the best means of disposal is by dumping on land then careful selection of sites and management of the tipping are essential.

For reasons that we have seen, however, this is essentially a counsel of perfection. As was made clear in the evidence given to the Key Committee, very often very little can be done in the manufacturing process to reduce toxic wastes that have to be disposed of; segregation is not always possible and in cases where it is, it may pose problems of storage and certainly of costs. In many cases the precise composition of the waste is not known with certainty and indeed it can be variable depending upon the manufacturing process. Therefore, although treatment methods can be devised for known toxic materials, it would be very difficult to provide a universal treatment for a waste of unknown composition.

One matter is very clear, relating to the use of land filling or disposal on land and that is the most careful control is necessary, particularly on large sites. As an instance of what can happen, it will be recalled that there was a very unfortunate fatality at such a site in Pitsea, Essex, in March 1975. The circumstances seem to be that earlier some sulphide residues had been deposited and presumably been forgotten about. When subsequently waste acid was being disposed of the acid reacted with the sulphide to produce a very high

concentration of hydrogen sulphide, leading to the death of a lorry driver.

Essentially, however the whole matter is or should be one of co-operation between the various interests concerned. The Streatfield Working Party identified three such interests: the waste producers, the carrier, and the waste processor or disposal site operator.

The code of practice calls for:-

i) The waste producer to ensure that his personnel conform to good practice.

ii) The carrier who is concerned with the removal of the waste to give a receipt for and collect and transport only those wastes which have been properly certified by the producer.

iii) In the case of hazardous wastes the waste producer shall give three days notice to the carrier of the class and contents of the waste which to be are collected and transported.

iv) The carrier shall ensure that the equipment and containers or vehicle used are fitted for their task and that his personnel are provided with protective clothing if this should be necessary.

v) Appropriate precautions should be taken when transporting hazardous waste material in line with those applying to other hazardous materials.

vi) The disposal site operator shall provide full information to the waste producer and the carrier, including particularly the nature of wastes already deposited at the site and an assurance that hydrological and the geophysical surveys have shown that the site is "safe".

Other codes of practice refer to the protection and segregation of the site and to the processing of wastes and disposal of wastes at sea.

In the context of the Control of Pollution Act the local authority may well be involved in at least two of these different categories.

Summarising the whole matter therefore the matter of dealing with toxic wastes is complex: the definition of toxicity is in itself difficult; cost of treatment must always be at a premium; and to ensure efficient operation there must be maximum co-operation between all parties involved.

Part II Disposal of Radioactive Waste

Section 101 of the Control of Pollution Act 1974 empowers the Atomic Energy Authority "to engage in the United Kingdom and elsewhere in such activities relating to the treatment or disposal of waste and other matter as the Secretary of State may from time to time specify by notice given to the Authority". In practice the authority works under the code given in the Government Policy for Disposal of Radioactive Waste Disposal[4]. The Ministry of Agriculture Fisheries and Food is responsible for determining of acceptable discharges into the environment and allows such discharges within certain limits. In a paper[5] presented at the European Nuclear Conference in Paris in April 1975 Dr. N.L. Franklin outlined the likely world nuclear programme until the year 2000 and

this is given in Table 2. The general introduction of fast breeder reactors from 1990 is assumed which accounts for the large increase in plutonium throughput. It is not my present purpose to become involved in the controversy about the production of plutonium by the fast breeder reactor; rather I would attempt to put into perspective the amounts of waste products produced in the generation of nuclear energy. It will be seen from Table 2 that the tons per year of spent fuel reprocessed for an installed world generating capacity of 50 GW is only 700, giving rise to 14 tons per annum per GW (or 1,000 MW).

It is the reprocessing of the spent fuel that gives rise to active waste, but the quantities involved are very low, as shown in Table 3. It will be seen that generation of 1,000 MW gives rise to only about 7½ tonnes of concentrated highly active liquid waste, which is the most intractable to deal with. This should be compared with the normal emission from a fossil fuel station of 1,000 MW capacity. Assuming that the station is operating on a load factor of 75%, as most modern stations do, the emission of sulphur dioxide amounts to 90,000 tonnes per annum and 500,000 tonnes of ash per annum are produced of which 80-85% is pulverised fuel ash and the remainder furnace bottom ash.

These figures should serve to put the matter into perspective.

Radioactivity is measured in Curies (Ci) which is defined as the number of disintegrations per second. As every schoolboy knows (or at least some schoolboys know) radioactive emission is of three types: alpha particles which are helium atoms of high energy but short range; beta rays which are fast moving electrons of longer range; and gamma rays which are a form of penetrating electro-magnetic radiation. The main problem isotopes with their half-lives are:-

Caesium_{137}	30.23 years
Strontium_{90}	28.1 years

the actinides -

Plutonium_{239}	24,000 years
Ruthenium_{106}	367 days
Niobium_{95}	35 days
Zirconium_{95}	65 days

Now an important point to note and a common misconception is that a very long half-life - by which is meant of course the time taken for the radioactivity of the substance to decay - is not necessarily a bad thing since, for example, mercury has an infinite half-life.

The main problem associated with radioactive wastes is that there is no known means of destroying their radioactivity once it has been induced. A major practical problem is that highly active wastes, by definition, maintain themselves at a higher than ambient temperature and if cooling is not practised the materials could overheat and volatilise - that is to say, escape.

The general philosophy of dealing with the highly active liquid waste was described by D.W. Clelland[6] in the symposium on the Management of Radioactive Waste from Fuel Reprocessing held in Paris in 1972. Clelland comments "the first possible method of dealing with waste which might be considered is disposal, that is relinquishment of control over the waste and abandonment of the ability to retrieve the waste. Since safe dilution of this highly active

waste is impracticable it follows that after disposal it would still be in a concentrated and therefore hazardous condition somewhere in the environment. Disposal therefore would rely on the waste remaining remote from man". Since this latter point could never be guaranteed the alternative method of dealing with the wastes is long term storage until such time as the radioactivity has decayed sufficiently for them to be safely discharged into the environment. It is this longer term storage that has to be carried out under carefully controlled conditions and under constant supervision, that has given rise to some public disquiet. Clelland further states that "siting of long term storage facilities adjacent to the reprocessing and solidification plants avoids both the hazard and the cost of transporting highly active waste through the public sector and offers the best facilities for monitoring and surveillance". In his paper in 1972 Clelland reported that the waste storage facilities at Windscale at that time comprised nine stainless steel storage tanks, eight of which had a capacity of 70 m^3 each and the ninth a capacity of 150 m^3, two further tanks of the larger size being at that time under construction. The whole of the concentrated liquid waste from the British nuclear programme is currently stored in some 12 tanks occupying an area of less than one acre.

The tanks are constructed to what are called "high integrity" standards in high quality stainless steel, niobium stabilised, with every weld approved by radiography. Nevertheless such tanks and equipment will have a finite life and there must be arrangements for replacing the plant in due course. Because of the obvious difficulties attached to long term storage of highly active liquids, much effort has been expended in finding methods of solidification, the preferred method being that of vitrification. The first commercial vitrification process is planned to be introduced by the French CEA at Marcoule in France. This system employs a rotary calciner with a continuous melter and is known as AVM. In this country a process of similar nature is being developed under the name of HARVEST which stands for Highly Active Residue Vitrification Engineering Studies and it is hoped that the first commercial scheme will be in operation by the mid 1980's.

Storage of the resultant vitreous mass will present much less difficulty, the preferred method probably being to immerse in ponds of water so as to maintain temperature control and generally to monitor what is going on by analysis of the water.

Very much effort and research has been put into developing the nuclear electricity generation programme and the safety record to date has been extraordinarily good. There is every reason to believe that given a stable society and a continued technologically based civilisation, the storage and ultimate disposal of radioactive waste will present no particular problem.

REFERENCES

1. Control of Pollution Act 1974 (Chapter 40) H.M.S.O.

2. Disposal of Solid Toxic Wastes. The Report of the Technical Committee on the Disposal of Toxic Solid Wastes. 1970. H.M.S.O.

3. Industrial Wastes - A Working Party document embodying a Provisional Code of Practice for Disposal of Wastes. The Institution of Chemical Engineers (London) 1972.

4. Government Policy for Disposal of Radioactive Waste. Cmd. 885 (1959) H.M.S.O.

5. Irradiated Fuel Cycle. N.L. Franklin. Paper presented at the European Nuclear Energy Conference, Paris 21-25 April 1975, and published by British Nuclear Fuels Limited.

6. High Level Radioactive Waste Management in the U.K. D.W. Clelland. Paper presented at the Symposium on the Management of Radioactive Waste from Fuel Reprocessing, Paris, 27 November - 1 December 1972.

TABLE 1.

Industrial Solid and Semi-Solid Wastes

Total Quantities in Tons Year

NOTES:
* includes weight of water
+ includes 830,120 tons of aqueous slurry
‡ includes 160,000 tons of slurry

Number of Premises included in Survey: 1186

Type of Waste	Surface Tips: Local Authority	Surface Tips: Other tips	Mine-shafts	Inciner-ation	Disposal at sea	Contractor, Methods Unspecified	Slurry etc pumped to settlement lagoons*	Other	Total
General factory rubbish uncontaminated by process wastes	120,296	669,437	-	89,688	250	259,455	-	18,991	1,158,117
Relatively inert process wastes	238,789	1,597,333	863,140+	6,934	173,639‡	453,828	5,601,380	238,450	9,173,493
Flammable process wastes	5,612	52,321	2,700	19,141	252	47,840	-	878	128,764
Acid or caustic wastes	17,228	244,714	-	4,257	50	47,324	113,000	2,784	429,357
Indisputably toxic wastes	1,457	149,213	3	1,173	5,981	42,294	-	1,556	201,677
TOTAL FOR DISPOSAL	383,382	2,713,018	865,843	121,193	180,172	850,741	5,714,380	262,659	11,091,388

TABLE 2. WORLD NUCLEAR POWER PROGRAMME

	1975	1980	1985	1990	1995	2000
1 Installed nuclear electrical generating capacity (GW)	50	300	500	1,200	2,000	2,500
2 Cumulative nuclear electrical energy sent out (GW-y)	120	650	1,850	4,350	9,000	16,000
3 Spent fuel (1) reprocessing load (t/y)	700	3,000	8,000	14,000	31,000	46,000
4 Cumulative fuel reprocessed (t)	2,000	9,000	36,000	90,000	200,000	400,000
5 Cumulative electrical energy associated with reprocessed fuel:						
(GW-y)	60	270	1,100	2,700	6,100	12,000
($kW\text{-}h \times 10^{12}$)	0.5	2.5	10	25	50	100
6 Plutonium throughput (t/y)	7	30	80	140	400	900

NOTES: (1) All fuel quantities are based on the equivalent of high burn-up LWR fuel.

TABLE 3.

Waste Generated

	per tonne of fuel reprocessed	per 1,000 MW installed capacity per annum	
Highly active	5 m^3		
Liquid waste (concentrated)	0.25 m^3	6 m^3	(say 7.5 tonnes)
Medium active (10Ci/m^3)	60 m^3		
Liquid waste -			
Yielding bituminous waste	0.1 - 0.5 m^3	2.5 - 12.5 m^3	(say 2.5 - 12.5 tonnes)
Highly active solid waste	0.25 - 0.6 m^3	6 - 15 m^3	(say 6 - 15 tonnes)
Fossil fuel generating stations:-			
SO_2	-	90,000 tonnes	
Ash	-	500,000 tonnes	

(Note: total U.K. electricity generation is approximately 55,000 MW)

National Society for Clean Air

43rd Clean Air Conference Edinburgh

11-15 October 1976

Part 2
Opening Address
Presidential Address
Reports of Discussions

nsca
136 North Street
Brighton BN1 1RG
England

CONTENTS

* These papers were not included included in Part I of the Proceedings but will be found at the end of Part II

OPENING ADDRESS BY THE LORD PROVOST OF EDINBURGH, THE RT. HON. JOHN MILLAR

Mr. President, Ladies and Gentlemen. Having just returned from a few days' holiday in the Channel Islands, I can speak with feeling on the subject of clean air. The lovely air on the island of Jersey was really invigorating and made one realise the benefit of having a clean, unpolluted atmosphere. However enthusiastic I might be to speak on the subject, my task this evening is to welcome you to Edinburgh where, I assure you, the air is a great deal cleaner than it used to be.

I have seldom known a conference where the literature on the subject has been so detailed and so well and intelligently published, and I would like to compliment whoever was responsible.

Clean air, of course, is only common sense, but I know only too well that habits tried die hard and Societies such as yours can do so much to enlighten and commend. The topics for discussion at your Conference are difficult and, no doubt, also the remedial measures are complex. I give you my best wishes for a very successful Conference because I know the good work you are trying to do. I was very interested in reading the handbook to see how widely represented the delegates are and I think it speaks well for the interest people are now taking in having a clean atmosphere.

I learnt this morning that Lord Kirkhill, Minister of State for the Scottish Office, had been unavoidably prevented from being present this evening to accord the Government's blessing and to open your Conference. While I cannot speak on behalf of the Government, I do know that your work is of great national importance, transcending narrow political frontiers. There is an old Arab proverb - 'He who has health has hope; and he who has hope has everything'. There is little doubt that clean air is one of the fundamental requisites of good health and your Conference is of great importance in a world where pollution seems to be a national by-product of many aspects of so-called progress and development. This by-product is a hazard which is the basis for your deliberations. And so, Mr. President, in addition to welcoming you to our great Capital City, I am now honoured to declare open and thus initiate the 43rd Clean Air Conference.

PRESIDENTIAL ADDRESS BY PROFESSOR P.J. LAWTHER

My Lord Provost, I am grateful to you not only for getting us off to a good start but also for doing so at such short notice. The "hymn sheet" has, if I read it correctly, the ominous information that I am to make a Presidential Address. There was a time, Sir, and on reflection it seems like an era, when one of our distinguished members used to follow me around to every lecture, (I can only believe that he was doing it under instruction from his Father Confessor to expiate some terrible sin, because I can imagine nothing worse than following me around) but he did it for about a year. He used to sit in the front row. He used always to ask me the same question after my talk and sometimes he got different answers. He complicated every lecture I gave by unnerving me and making me shuffle my slides even more furiously and adopting a tactic which I have used eversince - I had to include at least five slides which he had not seen and some of which I had never seen; and every jest I was wont to make had to be altered. The point in my recounting this tale is that a lot of you are following in his footsteps and have been following me around for the last 18 months since I've been your President! So tonight, not only am I bereft of slides and jokes, but also I know that you have heard almost every single platitude and truism that I have to utter on pollution. This makes my task tonight absolutely desperate. Some of my good friends here will know that this is not an affectation; I sweat blood before giving a talk; I sweated it on the Flying Scotsman and still have come to no firm conclusion, as Mr. Ebden says. I got into the Unit this morning at about eight and desperately ransacked the office to see if I could find the files on the Brighton meeting last year, and the Leicester meeting and that at Guildhall. I did not write anything down for Guildhall, which was last Monday, and could not think of anything else to say. When I read the transcript, made by our delightful Secretariat to whom you have paid tribute, Sir, I found that I had said almost everything before. I thought possibly the only just thing was to take up where I left off, and quote the last paragraph of my Presidential Address last year - "There is much difficulty in maintaining a state of perspective and of proportion. Alarm can produce fatalities by causing stess and depression. Watchfulness, careful research and the patient assessment of data must be the basis from which this excellent Society determines its customary policy of giving sound guidance to the public and politicians alike." You know by hobby-horse, about the danger of over-stressing environmental problems and, as a practising clinician, I see many people who are terrified that they may have lead induced brain damage through living near a road! The wife of one of our Consultant Chest Physicians telephoned me the other day in panic because she had brushed her garage roof and had subsequently discovered that it was made of asbestos and was afraid that she would die. I see unhappy effects of drawing the long bow and, in meditating north of Berwick, I thought the only theme that I could make any sense of was not merely that panic, depression and general suffering may be caused by Scientists who overstate their case, but that the last year has seen a lot of suffering caused by Scientists who did not need to overstate the case but who stated a muddled case.

There are three topics on which there has been much unnecessary muddle which has caused so much unnecessary suffering. The first, of course, is the vexed question of lead in air. There have been people who thought that airborne lead contributes such a high percentage of the burden of body lead that it has caused brain damage in children. I would stake what professional reputation I have in saying that there is not one tiny bit of evidence to justify these claims. But I will bring you the good news which I gave in Guildhall last Monday, and quote from memory the most recent figures - the most recent results of a good research project in Birmingham. In that City, in which there has been so much worry about Gravelly Hill, it was demonstrated by good methods, by sound scientific technique, by patient research, and by the use of facts undistorted by emotion, that of 841 children in a lead-polluted zone, due not to motor cars

but to metallurgical industries, the 11-plus results were better than those of a statistically proper control population of 1642 children in a non-polluted zone. I do beg you to believe that I do not say that lead is good for one but I do think that it is about time that public alarm was at least allayed by the emergence of some results from some careful work done by people who are proper epidemiologists. This does not mean that I would not welcome tomorrow the substitution of lead in petrol by some other "wonder-chemical"; one hopes that this will come about.

In the meantime, I can tell you that we have done some research recently. We have bled ourselves of course. We have analysed the blood of 58 children in a school in Newham (which is not the most salubrious part of London); we did not bleed them ourselves because I firmly believe that to bleed normal children is a kind of sport that I do not indulge in. I bleed sick children if it is necessary for diagnosis, but the reason we got the blood was that the district community physician was wanting to estimate the measles antibody titre to see whether these children should be vaccinated. We said to him "If you have any spare blood let us have it and we will determine the blood lead". The upper paediatric limit of normal accepted by Great Ormond Street is 35 micro grams per 100 ml. The mean of samples from 52 children selected at random that we analized was 9.2 micro grams per 100 ml. This would seem to me to indicate that air-borne lead is not a major contributor; I think that it is likely that food and drink are more important, no matter what my opponents might say. And why should one have opponents? Why this polarisation? None of us wants to send children "bonkers". Our findings of a mean of 9.2 with a range of 4 to 16 is a great comfort to me. In my unit we have all submitted to the process of having our blood lead levels estimated and they range from 8 to 23 - well below the paediatric limit of normal. We have done another hundred analyses on these Newham people, including Schoolmasters, and the range is 12.2. I give you these figures merely as reassurance; they comfort me. This does not mean that we give up research. We are plodding on, playing off the back foot; hoping that, maybe, reason will eventually prevail. The advice that I gave our Society last year was that this is no longer a medical problem; it is a socio - economic - engineering problem. You can abolish lead and carbon monoxide tomorrow if you use public service vehicles fueled by diesel-powered engines in the streets. They do not emit lead; they do not emit carbon monoxide. Maybe that is too uncomfortable an idea.

The other pollutant that has recently become popular is ozone. I am not saying that ozone is good for you; I am merely saying that again, needless anxiety has been caused by the fact that the problem has not been properly stated. I was taught, in the classic tradition, that before I started any research I should ask myself a question, nay, write the title of the paper I hoped to write. But some have not defined the problems posed by ozone. There are two packages of ozone which are bothering the environmentalists; one is stratospheric ozone, with which the propellants from "aerosol" cans may eventually interfere. These propellants chloro-fluoro hydrocarbons, are fairly stable compounds which last long enough to migrate to the stratosphere and can mop up ozone. The ozone up there is a good filter for ultra violet light. Now we need ultra violet light, but the doom-type people, to whom we owe a debt, forecast that if the ozone layer is depleted, more ultra violet light will reach earth and, instead of making us all browner and happier and saving us buying sunlight lamps, it will produce more skin cancer, malignant melanoma. Dr. Wise said, in the Clean Air Council on Friday, that he saw about four cases a year. This is pretty small in comparison with many diseases. The best calculations that I have seen on stratospheric ozone, have come, not unnaturally, from Harwell: the increase in ultra radiation might be equivalent to moving from Manchester to Brighton. Ought we to forbid sunbathing?

But this problem is confused with another problem. If very strong sunlight acts on pollutants derived from sources of combustion, especially from motor cars,

then you may get, by a photo-chemical process of some complexity which I do not understand, an increase in ozone. It occurs only in very hot weather, bright sunlight, and it is very "lumpy". You can almost smell the lumps of ozone drifting by and it has been said - truly because we have been measuring it, as well as has Warren Spring Laboratory - that we have in the last heat wave exceeded the maximum allowable concentration in industry for ozone. Now the alarm that produces may be just, if you accept that the maximum allowable concentration acceptable in industry is derived from sensible figures (Philip Drinker used to call these figures not an estimate but a "guesstimate"!)

There are two approaches that we have used in this recent episode; we found that there was an increase in mortality. You did not need to ask the epidemiologist or the statistical people for the reason: you needed to ask the mortuary porter at Barts. He was wheeling bodies over from the wards because of heat stress - not because of any effect of ozone. The people who had died were not people who were normally fit and healthy - they were people who are terminal illness cases who could not cope with the extra load on their heart produced by the need to sweat and the need to dilate their capillaries. You may think, "so what? That buried the effect of the ozone." I must in defence say that in 25 years of very expensive research in Los Angeles, nobody has demonstrated to my satisfaction - or to anybody else's - that there are any effects on health from levels of ozone which, not only once in a century, but once virtually every week, exceed 0.1 ppm in Los Angeles. Of course we have used experimental techniques. I had my lung function measured every morning on arrival at work when the ozone was high. I am delighted to say that my lung function results did not show any change at all. This does not mean that we just shrug it off - just that we try not to scare people about it.

The other muddle which is regrettable and, to my mind, incomprehensible is the asbestos scare. All the time I kept thinking that someone would appear on television and put peoples' minds at rest. I see frightened people in Outpatient clinics; I saw a docker the other day who was not only white and sweating, but also shaking. He had got the idea that "one fibre kills" - he had got this idea from several reputable newspapers. To my mind it is absolutely extraordinary that this kind of scare is put about without somebody having told people the facts. Asbestos is not the name of a mineral - it is the name of at least six minerals. The only thing that they have in common is that they are fibrous silicates, and every one is capable of producing certain effects. The most benign, as Professor Crofton, who is my honoured guest tonight, would agree, is that if you cough and produce a bit of spit, you can, if you look carefully, find in the sputum a thing called an aspestos body, which is of no significance at all other than at one time you have inhaled a fibre of asbestos. 70% of you have done so. It is of no clinical significance at all. The other benign effect of inhaling asbestos is to produce fibrous fatty plaques in the pleura and, if you go on inhaling it, you may get calcified plaques. There is a whole area of Finland in which there is so much anthopyllite - one of the asbestos minerals - in the soil, that all the farmers have got calcified plaques and not a bit of harm does it do them. All these effects can be produced by inhalation of any type of asbestos. Any of the asbestos minerals can produce asbestosis, a disease of the lung which is characterised by diffuse fibrosis, with impairment of gas transfer and breathlessness. You cannot get this disease from your ironing boards; you have to have worked either in the asbestos industry for many years in the bad old days, or as a lagger in a power station, or hacking off scrap metal or something like that.

Having said that, there is another feature of a danger of asbestos - lung cancer. There was an increased prevalence of lung cancer in the asbestos industry. I do not know whether Professor Crofton will agree about this, but the excess of lung cancer is among those who also smoke; Selikof's view is that an asbestos worker who smokes increases a hundred times the risk of getting lung cancer than one who does not smoke. Among these six minerals there is a blue one, crocidolite,

which has now been banned here. There is good evidence that the inhalation of a little of this mineral can produce a malignant tumour called mesothelioma. But do not scrap your garage; do not ring me up because you will not get a mesothelioma or asbestosis from your ironing board; you will probably not get it at all now. To me, a sad thing is that "officialdom", whatever that is or wherever it is, did not seek to alleviate this suffering by spending three minutes on "the box", or three minutes on the Today programme, by putting to you what I have just put now. These are three areas in which unnecessary suffering has been caused.

I am delighted to see that our Society, in the next week, is grappling with real problems. It has been grappling since 1899 with the very real problem of coal smoke and smoke control; there is still plenty to do and there are sessions here devoted to it. I am delighted also to see that it is grappling with the question of noise. To me, a loud motor bike going past in the middle of the night, or a motor bike going past me any time, shatters me; and you are dealing with that kind of problem. You are dealing with the real problem of waste disposal, solid waste disposal and liquid waste disposal. So forward-looking is our Society that it is dealing with alternative methods of production of energy such as the use of Solar Energy. These are the problems to which the Society is addressing itself. I have always said that the strength of this Society is that it makes recommendations not on bad science (of which there is plenty) and not only on common sense (of which there is also plenty), but on good sense and I wish you a happy Conference.

SESSION 2

NOISE AS AN AIR POLLUTANT
Dr. A.J. Crosbie

THE INDUSTRIAL AND LOCAL AUTHORITY APPROACH TO NEIGHBOURHOOD NOISE
J.H. Richardson and R.W. Smith

Mr. C.R. Cresswell (Principal Environmental Health Officer, Newcastle upon Tyne) said it was difficult to ascertain from where the figures came to support the view that ambient noise levels throughout the country were rising at the rate of ½ or 1 dB(A) per year. Considering Dr. Crosbie's point on the absence of a simple, foolproof and economic recorder which would permit an overall monitoring system, similar to the National Survey of Air Pollution, Mr. Cresswell thought we were a long way from devising an economic recorder which could be of value in a National Survey. Even if there were one, it was debatable whether the information provided would have much country-wide value. One of the most useful attributes of daily smoke and SO_2 monitoring was that the results enabled Local Authorities to tell whether average concentrations of pollutants in the vicinity of a particular site were rising, falling, or were stationary. This information was extremely helpful and nothing prevented anyone carrying out a similar exercise with noise levels. Depending upon the site, the period of time spent monitoring on a particular day did not have to be excessive or at frequent intervals in order to build up a picture showing the trends in ambient noise levels. Over a period of time, such an exercise repeated at a number of sites would gradually prove to a local authority whether the measures taken to reduce noise were succeeding, or whether possibly a new approach was required.

He agreed with Dr. Crosbie on the difficulty in drawing up noise contours for planning or any other purpose. This was one of the few errors in that otherwise very good Circular 10/73 'Planning and Noise'. Planners were encouraged to believe that noise contours could be drawn up which they could use in dealing with new applications for development.

It was impossible at present to find a noise index that could not be criticised. Progress was being made, however, and Mr. Cresswell thought it should be remembered that the Noise Advisory Council had recommended the adoption of a unified scale, and considered that the advantages of a simple scale such as Leq outweighed any uncertainties that may attach to particular values. A Working Party of the Council had concluded that the scale of Noise Pollution Level was more faithful to human reaction, but that more research was required before its adoption over the simpler Leq scale. Leq certainly had many advantages when measuring construction noise or the levels for noise in a noise abatement zone, but it was far from ideal, and most people working in the field required much more experience in its everyday use before suggesting the direction in which improvements were required.

International domestic noise levels had risen as the amount of mechanical equipment to be found in each house had increased. There also appeared to be a number of examples of individual equipment where, far from improvements being made, the new models had become noisier over the years. Mr. Cresswell remarked that his wife's new electric carpet sweeper had a noise level of 88 dB(A), compared with the older similar-sized model which emitted 75 dB(A) - both measured at 1 metre. There seemed to be a dearth of information about noise levels from domestic equipment of most types. Perhaps the quiet town experiment currently in operation at Darlington would provide some useful information which could be applied with advantage to reduce noise levels.

On the question of the use of transistors in streets and public places,

Mr. Cresswell said it was interesting to note that the Home Office persistently refused to approve the extension of existing bye-laws, or the adoption of new ones, dealing with such things as music in the streets, etc. The reason given was that there was sufficient provision for the prevention and suppression of that type of noise under the Control of Pollution Act 1974. Newcastle disagreed strongly and had, along with the Northumbria Police, made representations to the Home Office but, to date, to no avail.

He considered that the question of planning and road traffic noise, had to be watched carefully. Traffic management schemes under which, ideally, noise was taken to noise, would undoubtedly reduce noise levels in numerous relatively lightly trafficked areas, but could at the same time, produce some extremely high figures for the residents alongside the highways to which the traffic had been directed. For example, a recent, similar exercise in Newcastle had produced an 18 hour L10 index of 77 dB(A) at dwellings alongside what had been a wide but comparatively quiet highway. No doubt, the number of people who benefitted far outweighed those adversely affected, but an L10 of 77 with no compensation or redress was a great deal to impose on a section of the community.

He remarked that Dr. Crosbie had not mentioned the Institute of Acoustics. Although a new organisation compared with the NSCA, it contained a number of people from a variety of backgrounds with a common interest and provided an extremely useful forum for the exchange of views and information from experts in different areas of acoustics to one's own zone. The introduction of a new Diploma in 1977 should lead to a general improvement in the standard of knowledge.

He thought it a pity that Mr. Richardson and Mr. Smith had not referred to Circular 10/73, 'Planning & Noise', which provided good guidelines for use when considering noise in the context of development applications. When it was first issued it gave every Local Authority the opportunity to ensure that the effect of noise received adequate consideration at the planning stage. The Secretary of State had made it perfectly clear that the DOE would strongly support Local Authorities acting in accordance with the Circular.

He disagreed with the authors that the overall aim of Local Authorities was to minimise the number of complaints from the local community. In his opinion, the task of the Local Authority was to hold steady, as far as practicable, ambient noise levels and, wherever possible, gradually achieve a reduction. Progressive Local Authorities were using Circular 10/73, prior approval in respect of construction noise, and noise abatement zones, to achieve those ends. Table 2 in the Paper also used complaints as a method of assessing community reaction. He did not deny that regard must be had to complaints but he did not think they could be relied on as an accurate barometer of public opinion in the majority of situations. He suggested that it was preferable to rely on ensuring that the best practicable means had been adopted, and that there was no increase in ambient noise levels, unless absolutely unavoidable.

The Paper gave the impression that measurement or prediction of noise levels was usually necessary. He disputed this particularly, for example, on construction sites, or for noise sources outside noise abatement zones where it was usually possible, with some experience, to assess what the best practicable means in a given situation were, and to ensure that they were adopted. He also pointed out that noise abatement orders gave a Local Authority power to limit and possibly reduce many noise sources not normally thought of as industrial, for example, commercial premises such as launderettes, fish and chip shops, etc.

Reference was made in Case 5 to an Leq of 75 being acceptable. He thought it was a pity that appendix D of the Code of Practice made reference to it being possible to limit the noise 1 metre outside the nearest noise sensitive building between 7 a.m. and 7 p.m. to an Leq of 75 dB(A). Once a figure had been quoted,

although it might well be intended as a maximum, it became rivetted in peoples' minds as the acceptable level. He considered it may have been better if the British Standards Committee in the Code of Practice had quoted, for example, three different levels, and had described the circumstances in which they may be acceptable. The level suggested had been based on proposals in the Wilson Committee Report published thirteen years previously when the Committee were concerned with noise temporarily introduced into a district and the criteria proposed was that the noise should be such as not to interfere unduly with speech in the nearest inhabited building. But life had changed greatly over those thirteen years and the advancement in knowledge of noise control had been such that higher standards, that is lower noise levels, should now be capable of achievement.

He said that although he did not wish to appear a cynic, in Case 7 he wished the Company, the local residents and the local council the best of luck with their Committee. That type of organisation was often thought to provide the best answer, but in his experience such groups were invariably time consuming, frustrating, and very rarely satisfied any of the parties involved.

Mr. G.W. Barrett (Central Electricity Generating Board) referring to Mr. Cresswell's remark on the suggestion that noise was increasing, commented that no recorded figures were available to support this. In other areas of atmospheric pollution figures were available. The National Survey had shown that, in the main, urban air pollution had reduced over the past twenty years. Figures could, however, be produced which showed that in some restricted areas it was highly likely that noise pollution was decreasing. Over the last few years noise complaints made about power stations to the CEGB had been recorded centrally. The analysis of those complaints showed that after an initial peak in 1971, the complaints had decreased. The latest figures showed that this decrease was continuing for the years 1973-75. The CEGB liked to think that the reduction in the number of complaints was the result of a deliberate increase in its efforts to control noise. Those efforts had started in the 1960's and the newer power stations designed at that time had entered service in about 1970. Much more stringent noise control techniques were employed at the new power stations. However, if the suggestions that noise pollution was increasing were true, did this not suggest that the growing battallions of noise control consultants, delivering growing mounds of papers at increasingly numerous conferences, were being remarkably ineffective? In the field of workers' exposure to noise, did it mean that if levels were increasing on the factory floor, that there was a failure of the Government's voluntary Code of Practice For Reducing the Exposure of Employed Persons to Noise? If this was so, was it not time to do away with voluntary methods and introduce far more effective legislation? He did not agree with the conclusion that noise was increasing, neither did he believe that harsher laws were necessary. But he did believe that one should not make claims about increasing noise levels without full documentary backing, otherwise one would only succeed in increasingly alarming the public.

Professor R.S. Scorer (Clean Air Council) felt he had to take up Mr. Cresswell's challenging suggestion that there was no reason why we should not have just as effective measurements for the control of noise as we had in air pollution. It was, he said, easy in principle for physicists to invent methods of measurement, but noise was not necessarily objectionable. He liked motor racing, but would not want the noise that went with it anywhere else. It had been suggested that notices would be effective in reducing the noise made by people going home from parties, shouting in the street, slamming car doors and so on, on the grounds that the better the party the better humoured the people would be, and the more notice they would take: he suspected that on the contrary the better the party

the greater the inclination to be noisy. We had at present a plague of noisy small-capacity Japanese motor bikes. This was, he considered, an example where no-one liked the noise except possibly the rider for the first few weeks; here was a very specific piece of machinery that could easily be controlled by legislation.

He considered that we lacked organisation: we were attempting to make one subject out of several and expected to find one method of control. This was like mixing different kinds of fruit together and then attempting to grade them all according to a very simple criterion.

Professor Scorer said that he had grown up in a city where there was a forge making drop stampings. Mr. Bottomley from Lincoln would know the one he meant. It had operated for a long time, day and night, like gunfire going on intermittently all the time. Yet in this same city, the cathedral clock which had been used to striking every quarter of an hour and had done so for centuries had recently been stopped from striking at night because people had objected to the noise. He thought that this kind of thing indicated that noise was much more subjective than Dr. Crosbie had suggested.

It reminded him of the story of the oriental gentleman who had expressed a preference for the first item on the programme of an orchestra, meaning the warming up before the conductor appeared: he had preferred each instrumentalist to do his own thing rather than to have the noise organised, and this could be a genuine reaction. Refinery noise could be objected to when it was no more intense than the noise of crickets or grasshoppers in a field in Spain. People leaving a party made less noise than a cookaburra - and who could object to that hilarity.

He considered that noise was more analogous to the qualitative aspects of odours, which involved much personal preference. In driving up to Edinburgh he had passed through a part of Cheshire which smelt like a mixture of pig farms and cheese factories, but if that was put in the middle of London there would be noisy complaints. He said that there was no single physical aspect of noise or smell which could be a valid criterion of acceptability: an orchestra warming up was the same sort of noise as a Haydn symphony, only differently organised. With luck, the cathedral clock could be allowed again to strike all night: it needed active public relations to achieve this.

He wished to congratulate the authors, and particularly Mr. Richardson, for their emphasis on consultation. Last month he had been at a conference in Utah just after the National Academy of Sciences had published a report which included the recommendation that any regulation of the release of fluorocarbons could be delayed for up to two years. He had suggested that this time should be used to do the kind of thing we thought we were rather good at, and that there should be consultation between those doing a thing and those wanting to stop them, rather than to use the adversary method, used in North America and which was beginning to be considered in the EEC, whereby a prohibition was made, followed by prosecution of offenders. Consultation was not allowed: the suggestion that the control agencies should consult with the fluorocarbon industry had been received with horror. He considered that the idea that people with power should get together to diddle the community into accepting their compromise was illegal anyway: obviously the government and business could not be trusted.

It seemed to him to be more of a disaster than the thing itself, and he thought that this country had something very important to offer. In the EEC it was being suggested that the country should be covered with noise meters, or pollution meters, for then we should be able to regulate. But Professor Scorer felt that if we did not push our methods there was a danger that Brussels might soon be

telling us to put up meters everywhere. 'Harmonisation' was what they called the drab uniformity imposed by bureaucrats a thousand miles away.

Saying that Mr. Richardson had referred to something like "failure of planning authorities to put restrictions on developments in advance", he thought that the implication was that people should be told in advance what they must not do. Instead, he considered that if you were intending to do something, you ought to be aware of its impact on others; it was not the responsibility of the authority who had not met anything like you before. Putting it briefly, he stated that the onus was on the owners. He emphasised that we had to get it accepted that everyone had responsibility for what they did, not that they could do anything that was not prohibited.

Mr. G.R. Charnley (Southampton C.C.) pointed out the need to differentiate between satisfactory design standards for noise and nuisance noise levels. Because of the wide variation in subjective response, the Government had framed legislation so that a subjective appraisal should be made by the Environmental Health Officer of any individual problem, rather than the use of the sound level meter to 'justify cause for complaint'. In this respect, and bearing in mind that the assessment of an Environmental Health Officer could often mean the outlay of thousands of pounds in remedying a particular problem, he proposed that any hearing was of a reasonable standard. Too much emphasis was currently being placed on the use of sound level measurements in assessing complaints, and although such measurements and the use of various standards were often essential in deciding the means and degree of abatement, they should only be used for the latter purposes. British standard 4142 must certainly also be used with some reservation in proposing suitable design standards. Mr. Charnley pointed out that 'noise levels which were of marginal significance as regards likelyhood of complaint' often verged on 'nuisance' proportions.

He criticised Mr. Richardson in his use of British standard 4142, for assessing noise from a night club in his lecture, emphasising the title of that document (i.e. 'a method of rating industrial noise affecting mixed residential and industrial areas'), and suggested that document ISO R 1996 would have been more appropriate, especially as the methodology of comparing the noise complained of with the back-ground noise was similar in both documents.

Road traffic noise was one of the greatest pollutors of our time, and standards set in the Noise Insulation Regulations of L 10 (18 HR) 68 dB(A), still gave rise to more than 40% of the population exposed to such levels being dissatisfied with those levels. An important anomaly to note, he added, was that whilst protection was given, to some degree, to residents living by newly constructed roads or additional carriage-ways, under the regulations, no protection or compensation was provided where traffic flows could for example be substantially increased by rerouting of traffic on existing roads. 'Heavy lorry routing' was highly significant in this respect.

Mr. F.A. Sims (Executive Director of Engineering, West Yorkshire M.C.C.) commented that Dr. Crosbie's paper stressed the limitations of noise measurements and the possibility of disagreement on the basis of measurement and also on the psychological effects of noise. There was some evidence that the vast majority of people accepted a high level of noise without complaint. This was perhaps particularly true in the short term. He expressed interest in Dr. Crosbie's remark that anti-pressure groups dismissed the non-complainers as the imperturbables. The second paper stated that a study of admissions to psychiatric hospitals had shown a correlation between noise level and admission rates for certain categories of mental illness. Mr. Sims thought the authors had high-lighted the divergence of views on the problem of noise and its effects. He

believed it was fairly generally accepted that noise under certain circumstances could achieve a high level without causing any damage to the ear in confined spaces - one would always take the example of a pop concert. He was interested in the case which involved the dredging company and the local authority. It said "they reached an understanding" and "reasonable compromise" was talked about. He wondered what would have happened if that "reasonable compromise" had not been reached, if the rules had been statutory rules which had been hard and binding - then in fact that dredging job would probably never have been completed.

As the promoting authority for public works, his was a heavily urbanised county and had to agree methods of meeting realistic standards for noise levels with five Metropolitan District Counties with powers under the Act. The working of the Act depended entirely on the reasonableness of the local environmental officer and the local committee on the interpretation of the Act. He was pleased to say that the co-operation and understanding between authorities was very encouraging and very satisfactory. However, he thought it should be remembered that compliance with the Act must involve the developer and the promoter or user in additional expenditure. This brought him to the point of the short-term noise intrusion, since he thought that in certain cases we may be producing degrees of control which nationally we may not be able to afford. As an engineer with a local authority, he was concerned at the rising costs of construction and the heavy burden that recent legislation was placing on the industry, and the impact that this could have on real work and real jobs. He was also concerned that much of the legislation being introduced had not been costed. He believed that the Control of Pollution Bill had not been costed, particularly the section relating to Noise. He gave as an example the fact that they had been told that they would not be allowed to use a particular type of pile to achieve a technical solution to an operation, particularly, say, with a railway possession. This could put the cost of operations up by 15-30%. Once that was multiplied into the multi-million projects in urban areas, costs could rise excessively. In referring to piling, he said he had only mentioned one section of the industry involved with noise. He then highlighted a case which happened long before the Control of Pollution Act. They wanted to undertake some complex roadworks and put the option to the local residents of either continuous working day and night over one weekend or intermittent working over several weeks. The local residents opted for the shorter period and day and night working - in fact they made the weekend into something of a party. Mr. Sims asked if this would have been what the environmental officer would have allowed, or could have allowed. He asked if levels of protection were being arranged for people who, in the normal course, could often be satisfied on operational grounds over short-term problems, but who if knowing that they had to bear the increased costs through taxes and services, would be reluctant to support the environmental approach. He stressed that his concern was with high cost, short-term engineering problems, not long-term projects for which generally reasonable compromises could be reached on environmental matters.

Mr. J.B. Douglas (St. Helens M.D.C.) asked if Mr. Richardson could give a reference for the table showing comparisons between Leq/L10 and L90.

Commenting on a remark made by Mr. Cresswell, Mr. Douglas said he understood that the British Standards Committee had subsequently regretted inserting the figure of 75 dB(A) Leq in B.S. 5228.

In a written contribution Mr. Douglas remarked that noise from motor sports caused problems throughout the country. His area were particularly concerned with noise from powerboat racing. International Sports Regulations (U.I.M.) referred to a figure of 85 dB(A) at 25 metres with a tolerance of 10 dB(A). His Authority considered this 95 level unacceptable and had agreed a voluntary limit of 85 dB(A) with the Club concerned. Despite protests from some competitors,

and some disqualifications, those levels had been maintained and at the last 'National' Race meeting the top racing team in the country fitted an additional car silencer to each of their boats and managed to win their races with speeds less than one second per lap down on previous races and with noise levels down to 85 dB(A).

Because of national interests the Royal Yachting Association had become involved and were putting forward a Code of Practice for the Sport using the U.I.M. standard. They were pressing for this despite evidence that engines could be quietened to lower levels. They maintained that most of the racing engines used were imported from America where, apparently, noise was not a problem and additional silencing was then difficult.

It was felt that where it was possible to get lower noise levels, then a higher level should not be specified. As was well known, this often lead to a reduction to the specified limit and no further.

The ultimate decision, of course, was whether or not a nuisance was being caused to the residents and a number of Local Authorities were concerned about this basic problem. A Working Party was at present investigating noise from sports activities and Local Authorities views should be made known in support of the best standard reasonably attainable (i.e. BPM).

Mr. P. Draper (Chairman of Council, Individual Member) said both papers had given a great deal of information on noise, particularly from the technical point of view and on its effects. As an engineer, he regretted very much not hearing another aspect, namely 'the reduction of noise at source'. He considered this far more important than all the methods of reducing the noise received by people in houses and elsewhere.

Noise could be reduced at source very considerably. He gave as an example the motor cycle business. Many people were plagued by machines with noisy little 2-stroke engines. Many years previously he had bought his son an almost silent motor cycle, which did not appeal to him at all! That was one of the differences of appreciation or depreciation of noise.

The question of getting used to noise was an important aspect. On arriving at his hotel he had asked for a quiet room. The receptionist said his room would be quiet as it overlooked the gardens. It did indeed but, between him and the gardens was Princes Street on one side and the railway station on the other. He thought that if the management of the hotel came to stay with him, they might be annoyed by the noise of the seagulls and curlews.

Noise could be reduced in other things. When in Switzerland recently, his hostess one day was vacuuming the carpet with an almost silent vacuum cleaner. He considered that was something to work on. The reduction of noise at source was of extreme importance and a subject which should be sponsored and developed.

Mr. T. Henry Turner (Individual Member) remarked that when smoke abatement societies were founded in about 1900 there were no nationally standardised air pollution measuring instruments. Progress in clean air followed the widespread use of devices specified by the British Standard Institution and made available in 1950.

We were now only at the beginning of noise abatement and the selective, directional hearing which humans needed and which rabbits and donkeys already possessed.

To eliminate harmful and confusing background noises one often needed not only

effective ear muffs but also the directional-hearing of long-eared animals. Almost everybody needed directional-hearing aids especially engineers at work and policemen or soldiers on night patrol.

When attending a lecture one could use opera glasses to read the small print projected on the far distant screen, but there was no similar portable device to focus one's hearing on the speaker and exclude the surrounding cacophony. He felt the time was ripe for the British Standards Institution to specify combined ear muffs and directional hearing aids.

Dr. A. Parker (Individual Member) said noise caused a personal reaction which differed according to the individual. What was objectionable to one individual may not be objectionable to another. Some people enjoyed classical music which others found boring. People travelled miles to listen to very loud pop music, which many lovers of classical music could not bear. Mr. Richardson had not mentioned instances, that did occur, of objectionable noise from one source, for example in a factory, causing further objectionable noise by producing sympathetic vibration in equipment in another part of the factory. He asked how Mr. Richardson dealt with cases of that kind.

Mr. G.W. Pickin (Corporation of London) dealt particularly with what he called 'unnecessary noise' which caused a great deal of suffering. In particular, building and highway contractors produced a tremendous amount of noise in urban areas. The City of London had perhaps a unique problem with a very small night-time population and a very large day-time population. In every highway, building, or demolition contract under his control there was a clause excluding the use of noisy machinery between 10 a.m. and 4 p.m. This, of course, could be adapted according to the circumstances in individual towns, but he thought delegates might feel that this arrangement could be followed a little more closely in areas other than the City.

A great deal had been said about lorry noise and motor vehicles and Mr. Pickin wished to emphasise a point made in one of the papers that motor vehicles, under the Construction & Use Regulations, were at present permitted to make a noise level of 90 decibels - the same noise as inside a tube train. He thought this was quite absurd. The sooner it was reduced to 80 the better. But, he said, he would not stop there because 70 was a radio at full volume and he really did not see why one should put up with this assault on the ears simply and, presumably, in order to produce more power; and that was why small motor cycles made so much noise - they were under-engined and were always driven "flat-out". The City of London was suffering from a rash of motor cycles because of the recent increase in fares and this would get worse. He hoped that the Society would put pressure on at the right places to bring about a reduction in noise levels in the motor vehicles Construction and Use Regulations.

One point that had not been touched on was helicopters. There had been pressure from the helicopter lobby twenty years previously to get an inter-city service going. This was an excellent idea, but the one thing that had really killed it was noise. The Corporation were assured that the manufacturers had the problem in hand and that noise levels would be reduced. The manufacturers were invited to come back when they had done so, and the Corporation were still waiting. But one suffered all the time from this resistance to reducing noise by the manufacturers of the various noisy plant.

Mr. Pickin's final comment was on tyre noise. Tyres were noisy in order to increase their non-skid characteristics and one had to accept compromise between noise and road safety.

Mr. J.J. Beagle (Principal Environmental Health Officer, London Borough of Hammersmith) reported that the London Borough of Hammersmith had made its first Noise Abatement Order which was at present with The Department of the Environment awaiting confirmation. The zone based upon three Wards of the Borough involved 121 classified premises and covered 568 acres. It also incorporated a conservation area and a traffic improvement scheme to effect the maximum environmental enhancement. So far only one objection had been received on the grounds of unnecessary expenditure of ratepayers money and this had been referred to The Department of the Environment after attempts at local level to get the objector to withdraw had failed.

The compilation of the Noise Register presented some technical problems in measuring noise levels from certain classes of premises. He asked how one measured the noise levels of individual industrial premises housed in the same factory block where the noise from each industry impinged upon the other, making individual noise level recordings nigh impossible.

Dr. R.V. Riley (British Steel Corporation) said that thirty years ago, having a tooth drilled at the dentist could be a traumatic experience, largely because of the very noisy drilling tools used. Nowadays one could scarcely hear the dentist's drill simply because it ran supersonically. Most of the problems in industry and elsewhere were caused by machinery running noisily. He asked if enough was being done to run machines which were beyond the audible range of the human ear.

Mr. D.B. May (Exeter City Council) commenting on Mr. Richardson's paper, wished to sound a note of caution. One should be wary of acoustic consultants, particularly the cowboys who had cashed in on this lucrative business. Such people often quoted noise units and indices as standards which were acceptable for general application, and perhaps supported their arguments with graphs and mathematical formulae. Such an approach overlooked the fact that indices such as CML, MMI, L10 (18 hour) etc. were in themselves compromises between recommended values and financial costs.

Residents who complained about noise did so subjectively. Local Environmental Health Officers, who often assessed a variety of nuisances, with no specific objective criteria to guide them were, he sugested, best suited to assess noise nuisances. They had knowledge of local conditions and attitudes.

He cited two'case studies' which he thought would be of interest. An acoustic consultant was called in by a manufacturing company to recommend the means of reducing a night noise level, which was judged to be a Statutory Nuisance. After extensive measurements, subsequently analysed by a computer, specified noise attenuation equipment was recommended. When, after a delay of nearly two years, the attenuation equipment had been installed, the noise emission level immediately rose from 48 dB(A) to 52 dB(A). A private individual would not accept the decision that a local authority should not institute legal proceedings to resolve her complaint of noise. She employed one acoustic consultant, at a cost of £90, who agreed with the authority's view. Still dissatisfied, she employed another consultant, at double the fee, who recommended that action should be taken. There seemed to Mr. May to be a moral there, somewhere.

Mr. A.G. Shankster (Stockton on Tees B.C.) raised a point in relation to the difficulties of reproducing accurate measurements which would be comparable, yet in his Figure 1, Mr. Richardson had given a variation of 20 dB(A), yet one of his slides had showed a 9 dB(A) reduction of noise over a period of some seven years. He asked if Mr. Richardson could comment on the comparability of those measurements.

He said that if any local authorities present were unable to afford sophisticated measuring equipment, he would recommend the 'Tally-mark' method as being one which would give reproducible results. For the benefit of those persons who were in doubt, he said that he had had measurements taken by experienced and untrained personnel together, and a result had been achieved within 1 dB(A). In relation to Mr. Crosbie's point about the person living next to a violin teacher being subject to nuisance, he thought that it was mainly the low frequency noises which were audible. He had always taken 6 dB(A) per doubling of distance for a point source and 4 dB(A) per doubling of distance for a line source and wondered if the reduction for distance involving frequency could be commented on.

Mr. R. Kidd (Newtown Abbey D.C.) wished to comment that no effort seemed to be made to illustrate to people the harm they did themselves by self-inflicted noise.

Mr. G. King (West Glamorgan C.C.) put in a plea for greater collaboration between planners and their environmental health colleagues, consulting engineers, etc. He said that planning authorities were now much more aware of stringent conditions that needed to be applied to some developments. Mr. Richardson's paper had referred to impact studies of noise being agreed between prospective developer or L.P.A. Mr. King thought that the very important implications of whose responsibility this should be was a key question in the Government's recent Working Party on Environmental Impact Studies generally. He considered that noise might be one factor amongst many others in assisting final decision making. In general, his opinion was that the cost of study should be borne by the applicant.

Dr. A.J. Crosbie agreed with all the points made and summed up his views as follows. In terms of the physical sciences we had, he said, the knowledge to understand noise generation and dissipation; in terms of technology we had the ability to do something about it, although he qualified that slightly by saying that some of the present day noises came from technological developments initially, such as hovercraft and helicopters, but we had the ability to reduce noise quite considerably. In terms of the behavioural sciences we were very far behind indeed. Professor Scorer had made an interesting comment about the Japanese - cultural differences were, indeed, very marked. If one went to live in a Chinese community one would wonder why noise was the subject of discussion that morning. The individual's reaction was worth noting above all.

One speaker had mentioned, in terms of the behavioural sciences which included psychology, geography, and sociology, the question of self-inflicted noise. He thought that in this respect everyone would agree that we all made noise, we were aware that others made far too much noise, and were thereby doing themselves harm. But he considered that we had a cautionary tale in the limited success of the campaign to abate smoking as a habit as to the probable effect of such awareness.

Mr. J.H. Richardson replying to the discussion said he wished to comment on whether one considered the "complaint" or an "ideal" design situation. He supposed most of the case studies cited had been ones in which his company had been involved, and generally they did not get involved unless the situation was serious enough to cause complaints. Most of the major projects referred to would have required considerable expenditure to get noise levels down to a marginal situation and virtually none of them could have taken place if no increase in background level had been permitted. He thought that a compromise was required, using the Best Practicable Means for reasonable costs.

A comment had been made on the assessment using BS 4142 for club noise in case III. In the full report it was mentioned that BS 4142 had been chosen as being typical, not ideal for the situation. In other words, it had been felt that it was certainly as good as ISO 1996 in that particular situation and it was an accepted standard within the UK.

The table of Leqs', L_{10}s' and L_{90}s' (slide No. 3) and come from an American publication - Noise Control Engineering, September/October 1974. Mention had been made of noise levels inside factories. There was a good Code of Practice covering this but it had been beyond the scope of his paper in any case, however a good deal of work was being done in that field. At present the maximum design noise level was 90 dB(A) and this might be reduced in the next few years. He thought that within the works, certainly the works that he had visited, the workers were aware of noise levels, they were wearing hearing protection if the noise levels exceeded 90 dB(A). In many cases the management were attempting to educate the people, they posted notices and people were interested in the work his company did. They saw sound level meters and immediately wanted to know what was going on.

In a brief mention of bird noise, Mr. Richardson said that one case in which he had been involved, macaws had been likened to noisy machinery in need of grease! Therefore not everyone liked bird noise and the activities of these particular birds had been restricted as a result of this case. With reference to the comments about consultants, he felt he could not lay down the gauntlet over that but that obviously there were good and bad consultants. It did not, necessarily mean that one had to pay a great deal of money. Certainly there were instances where people thought they knew something about noise and would do or recommend the wrong solution. Acoustic Technology Ltd. had been called in on situations like these to pick up the pieces. Very often the plant owner might call in the manufacturers of the particular piece of offending equipment who had sold them some piece of noise control hardware which was not the complete answer to their problem. That was thus a plug for good noise control consultants, not bad ones.

Turning to the comments on the last case study presented he said that those measurements had not been sophisticated ones, they had been simple dB(A) measurements. This was because the original measurements had been made in 1965 when this had been the most sophisticated means readily available.

With reference to attenuation with distance, he thought that 6 dB(A) per doubling of distance for a point source and 4 dB(A) per doubling of distance for a line source provided a reasonable minimum design guide. In practice if the noise levels had a fair amount of high frequency then the attenuation would be more than this and the O.C.M.A. guides which he had used would give a better assessment. This did mean that one had to analyse the source to establish the frequency content. Where this was not possible then the 6 dB(A) or 4 dB(A) could be used.

On the subject of Impact Studies he believed the onus was on the local authority to show that they were interested in noise and, as had been shown by the planning conditions, he thought most authorities were now interested. If the applicant knew that he was going to have to show that his plant was going to be acceptable, or at least, that he had done the best he could for that plant, then he should and often did do some form of an impact study. If he had not conducted a sufficiently accurate and trustworthy survey then perhaps the local authorities were in a position to put some input into this when it came up to planning consideration. If it was a very large project then perhaps the government could look at it in relation to other major projects going on in the same area. He considered that if the applicant wanted to build his plant, then he wanted the minimum complaints and preferably no complaints, but he also wanted to limit his expenditure wherever possible. The local authority was

therefore in the position when it granted planning permission, to safeguard the local community and the applicant.

SESSION 3

A REVIEW OF THE PRESENT POSITION AND THE WAY AHEAD
W.J.S. Batho

SMOKE CONTROL IN AN INDUSTRIAL AREA: EXPERIENCE IN NORTH EAST ENGLAND
L. Mair

Mr. I. MacPherson (Air Pollution Division, City of Glasgow DC) opening the discussion, said that both speakers had given everyone much to ponder on but not enough to awaken the sleeping tiger. Mr. Batho had expertly spoken on the energy crises, environmental crises, financial crises, concessionary coal, financing of smoke control, progress, the role of the Clean Air Council and, of course, the way ahead and the E.E.C. directives.

Mr. Mair, in contrast, had shown the thorny way of a devoted Officer in achieving what had been achieved in his area. A devoted Officer and devoted members were necessary ingredients for a Clean Air programme or campaign. The one without the other was a voice in the wilderness. Perhaps a few delegates would be asking what was being said that had not been said before. Mr. McPherson's reply would be that many delegates were new members who would be required to make decisions in the near future in respect of the limited finances available to District Authorities. He felt sure Mr. Batho would agree that with all the financial problems experienced in the past, never at any time had L.A. officials had to face up to the financial implications of Central Government Circulars at present before District Authorities. He asked Mr. Batho and Mr. Mair what advice they would give to elected members in the presentation of Clean Air as a top priority item. Should the message be one of gentle persuasion or should it be, as he believed, that the time had come to realise that clean air was long overdue in many parts of the country. The excuses, the frustrations, the problems, of course were there, as they had always been there. Should any one take a walk to any high ground above any village or any town, not covered by Smoke Control, on any autumn evening they would see a pall of smoke. This could not be tolerated. The very nature of domestic smoke was its low level and local pollution. It attacked the very young and the very old. It built in problems for the future and for the Health Service which had its own problems at the moment. The cost was hardly worth mentioning in respect of the benefits the nation could have from a clean, bright and healthy atmosphere.

The bravery of both speakers was to be commended in raising the controversial subject of concessionary coal. The coal industry, the mining community, the trade, and the National Coal Board had to face up to this. They had to accept that clean air was here to stay - it was not a passing phase.

They would have to come to terms with concessionary coal, do away with it if necessary, but the miners would have to be paid the equivalent in real terms. It caused more harm than it was worth in areas that were dragging their feet. Lip service was just not good enough.

On the question of E.E.C. directives he asked if Mr. Batho was trying to say that if local Authorities did not get a move on they would be told to by the E.E.C. He asked both speakers to comment on the merits and cost of monitoring, how long one needed to run it to know whether one had a problem or not. He thought the new members would like to know how black was black and how grey was grey.

Mr. J. Norton (Leeds M.D.C.) asked Mr. Batho when an increase in cost limits for smoke control appliances could be expected.

The present financial constraints were causing a slowing down of the operation of Smoke Control Areas. Delays in allocation of finance to whole-house improvements

meant that Smoke Control Orders had to be put back. The operative date could, by law, only be put back one year - any further deferment had to be by Variation Orders approved by the Secretary of State for the Environment. Both methods required staff time for administration, and a delay in having effective Smoke Control.

The present slowing down of Smoke Control was allowing a review of existing Smoke Control Orders to update existing exemptions. The resultant consolidation orders were easier to implement when smoke observations were being carried out.

Mr. H.E. Peaper (Fareham B.C.) said he had been very irritated with Mr. Batho's paper, and Mr. Iddison had mentioned that 3 years had passed before someone from the Department of Environment could bring local authority officials up to date. Mr. Peaper thought that Mr. Batho should be brought up to date at the same time. Referring to page 4 of Mr. Batho's paper, he asked Mr. Iddison to invite the Chairman and members of Health Committees and Environmental Health Officers and their staff present to stand up and be counted because Mr. Batho was daring to suggest that Chairmen of Health Committees required enthusiasm. Mr. Batho had also had the audacity to refer to 'a senior local authority official'. Mr. Peaper asked what was going wrong with those working in the DOE? Were they in fact changing over to the Ministry of Agriculture? Was it not after 20 years being acknowledged that Sanitary Inspectors, Public Health Inspectors, Medical Officers of Health and now the Environmental Health Officers had made this country clean - not Senior Officials of Local Authorities. He felt this point needed to be made clearly and honestly. He asked that Mr. Batho should stop sending out circulars on cut-backs, and instead indicate to the Chairman and the members of the finance committees of our councils that smoke control need priority, thus supporting Mr. Iddison. This country could then continue to be made clean, and he hoped Mr. Batho would explain this action to friends in Brussels. If their programme was any better than ours, then Chairmen and the members of the Health Committees and the Environmental Health Officers would meet that programme.

Mr. G.R. Millington (Wakefield M.D.C.) thought that Mr. Mair and he were on the same wavelength. Having read Mr. Batho's paper, then Mr. Mair's paper, he had considered that almost everything Mr. Mair had said about the North East could have been said about the West Riding of Yorkshire - the West Riding that used to be of course, because it was now part of West Yorkshire. He declared that he would tell a true story in which the names had been changed to protect the innocent. But, since he was at the conference as a delegate of the Wakefield M.D.C. the story would be about (   ) District Council, for the sake of discretion. He said this Council was half controlled, approximately, by smoke control areas and the quality of the air within that half was quite good. The other half consisted of mining communities which were reluctant to act. He asked what action had been taken when, many years ago, the DOE had had powers to force local authorities to carry on with smoke control. Local Councillors were under great pressure when considering schemes which they knew were for the ultimate benefit, but the immediate effects of which were perhaps going to be unpopular or to cost their neighbours or the people in the next street some money. What he suggested to Mr. Batho was not that he should bury the black and white areas so conveniently, as he had done in his paper, but that he should exhume them and reassess with Warren Spring Laboratory the black areas of the country, of which there certainly remained a number. He suggested that the black areas be put into the key sector of expenditure and that other areas could be allowed to remain in locally determined schemes. He asked that local authorities, of which there were some who secretly wanted instruction, should be told that they must get on with the job and clean up the atmosphere. He advocated increasing the government share of the grant from 40% to 50%, and, instead of (   ) District Council having a smoke control programme which now looked as though it was going to be extended for 50 to 60 years due to cut backs which had come about because of

Mr. Batho's indeterminate papers, he declared that if smoke control was continued, the U.K. could perhaps beat the E.E.C. to it.

Cllr. D. Biewer (Middlesborough B.C.) referred to Mr. Batho's comment about the DOE being in a dilemma when they had brought the Circular out. He wondered if Mr. Batho and his colleagues had contemplated the dilemma they were putting local authorities in? On the one hand local authorities were constantly being told that there was a financial crisis, and that they must not exceed the limit of their budgets. There were threats that if they overspent, there would be cutbacks and the rate support grant would be witheld. This was the real dilemma and it was the dilemma of the people in the towns who were paying the rates and taxes. One section in the Layfield Report on responsibility had been concerned with determining who was responsible for spending money. The conclusion had been that no-one would accept responsibility in 90% of financial matters. There was a similar problem in deciding who was responsible for smoke control. It was all very well to pass it across and say that the local authorities were responsible, when in fact the DOE paid the majority. He agreed with Mr. Mair that smoke control was not a local matter - it was certainly up to the authority as to how they progressed with it but it certainly was not up to that same authority as to its effects. Smoke control was not one of the most popular things to do: enough problems were created in the first instance in the attempt to convince people to go smokeless. What was wanted was a clear instruction to go ahead and the provision of money to do it. He was sure many authorities would welcome this.

Fortunately, there were boroughs which look ahead and Middlesborough was one. But up and down the country problems still existed and he was sure that if a clear instruction was given, this would lift the dilemma from these authorities, enabling them to get on with smoke control. One of the reasons for smoke control was not simply to enable people to breathe a bit of clean air, but in the long-term to create a healthier population, which would save the N.H.S. a lot of money. N.H.S. money was not local authority money, it was national money, and he thought that the responsibility should be taken at national level.

Mr. F.G. Sugden (Middlesbrough B.C.) disagreed with Mr. Mair on the question of the abolition of the grant for improved open fires. 89% of properties in Middlesborough were covered and he believed that a large part of that progress had been brought about because they had been able to offer a wide range of alternative appliances with grant aid. He appealed to the DOE to think again about the cut back, particularly because the areas where slow progress was being made were just the ones where, to get progress, it was necessary, if anything, to make grants more attractive. He feared, along with many members of the Northern Division, that if in the North East the grant position was made less attractive than it was at present, then there was no hope of any speedy progress.

The second point where he disagreed with Mr. Mair was on his appeal for special grants for the North East. Mr. Mair had spoken quite forcefully, suggesting that people in the South had for too long lived on the backs of the North East. He considered that the North East tended to spend too much time looking backwards criticising the people who had made the problems, instead of tackling the problem that existed. He thought Mr. Mair had overstated his case. The North East needed to stand on its own, especially with respect to smoke control. He saw no objection to some compulsion being applied but considered the 30% local authority cost was still reasonable. The local authority should pay it, the local residents should pay it because they were the ones who benefited from it.

Mr. G.W. Maxted (Kingston upon Hull D.C.) expressed concern about the future of smoke control and about maintaining the standards already achieved. Up to the present, smoke control had been spectacularly successful and he hoped this would

be sustained. However, he had reservations because of the disparity in cost between coal and solid smokeless fuels, which could range anywhere between 50 and 75 pence per cwt. Like many other authorities, by 1963 ⅓ of the premises in his authority had been subject to smoke control orders. Most of the householders had converted to the cheapest capital cost method, in most cases the modern inset open fire with integral gas ignition. The majority of the occupiers came within the stratum of low-income families and, at the time, with gas coke at a suitable comparative cost fuel to coal, there had been no difficulties. Gas coke had then disappeared overnight, throwing those people onto the expensive premium fuel market. There were difficulties in his area over enforcement work. He conceded that the national sanction of prosecution was available. But the law was only practicable if the majority of people were prepared to observe it. In this context, when a harassed housewife was faced with the choice of a joint of beef on Sunday for her family and a couple of bags of low priced coal, instead of high cost solid smokeless fuel, the joint won, and the low priced coal would be bought.

It was no use trotting out the concept of useful therm theory to those people, it cut no ice. If they had used 2 bags of coal previously, they would continue to use 2 bags of solid smokeless fuel. But many of the types to which he referred were just outside the benefit range. On the other hand, increased allowances made to those who qualified for such heating benefit were barely adequate to offset the inflationary spiral in the cost of solid fuel. He feared that if something was not done to help those people it could result in open revolt with which local authorities would be unable to cope, and there would be a subsequent setback to the air quality in our cities.

Mr. H. Giblin (Solid Smokeless Fuels Federation) in reply to the points raised about the sale of coal in smoke control areas said the Solid Fuel Industry was prepared to take action against coal merchants selling coal in smoke control areas by withdrawing their membership of the Approved Coal Merchants Scheme. This could make it impossible for them to obtain further supplies. Before such strong action could be taken, however, it was necessary for the merchant to have been prosecuted and found guilty of selling coal in smoke control areas. In this respect the support of the local authorities was needed to bring prosecutions against merchants breaking the law.

He was disappointed to hear that some delegates did not welcome the new DOE circular 54/76, which restricted grants for the replacement of approved open fires. As Mr. Batho's paper showed, the cost of clean air in 1975/76 was nearly as much as in 1973/74. Yet in 1973/74 there were nearly twice as many premises in confirmed smoke control areas as in 1975/76. Clean air, the same as everything else would cost more in the future and if it were to be progressed, expenditure would have to be watched most carefully. It was common sense, therefore, to retain appliances that had already been approved and were capable of burning the smokeless fuels that were in plentiful supply, rather than give a grant to replace them with some other appliance.

Mr. Giblin, referring to the comments raised about the high price of solid smokeless fuel, said it was an easy thing for householders to look at the retail price of 1 cwt of coal and 1 cwt of solid smokeless fuel and make a simple comparison. Unfortunately, they could not make the same comparison between the price of coal and the price of gas which was sold by the therm and the price of electricity which was sold by the unit. The true comparison in a smoke control area was to compare the price of all the smokeless fuels. The differential between the cost of coal and solid smokeless fuel did not vary a tremendous amount when one considered the higher rate of efficiency obtained when burning solid smokeless fuels as against burning coal.

Mr. J.J. Beagle (London Borough of Hammersmith) remarked that, owing to the restrictions in local authority expenditure caused by the economic situation, many councils who had not yet completed their Smoke Control Programme might be considering either curtailing or ceasing smoke control implementation. That would be a retrograde step.

The wisdom of the London Borough of Hammersmith, in embarking on a phased Smoke Control Programme in 1958, had fully justified the expenditure incurred. From 1958 to 1967, eighteen Smoke Control Orders had been made, involving 72,500 premises and covering 4,000 acres in the Borough. 17,500 conversions had been carried out. The net expenditure had been £156,000 and, with an average population during this period of 218,000, the cost per capita had been 72p. Over the nine year period it took to bring about Smoke Control Areas, the cost per capita had been 8p. per annum.

That represented wonderful value for money, even allowing for inflation, were the amounts to be costed in terms of current prices. Mr. Beagle therefore asked those authorities, still considering whether to incur expenditure on Smoke Control or on other projects, to give Smoke Control priority.

Dr. A. Parker (Individual Member) thought that one disappointment in relation to smoke control was that employees at coal mines in certain areas, who received concessionary coal, had not accepted the offer by the National Coal Board to provide solid smokeless fuel in place of coal. That offer had been available for many years and was still available. Miners complained that the amount of solid smokeless fuel allowed was less than the amount of concessionary coal allowed. They had not allowed for the fact that the amount of useful heat provided in a house by a ton of solid smokeless fuel was appreciably greater than from a ton of bituminous coal; or was the reason that many of them received more concessionary coal than they needed and that they were able to dispose of the excess at a price?

Professor Alice Garnett (Air Pollution Research, Sheffield University) commented that passing reference had been made to the question of air pollution monitoring. On behalf of local authorities who knew that they had problems or that more information was needed regarding variations in air quality in their localities, she wished to make a plea for grants to be made available to help meet the cost of providing additional and perhaps better apparatus for the monitoring of pollution, locally. The apparatus widely used for the mean daily sampling of smoke and SO_2 had been very useful, so far, in giving general indices of conditions present, but for the correct assessment of these and other pollutants there was often a real need for the use of apparatus sampling on a mean hourly and not a mean daily basis. Modest mean daily levels might often appear to indicate that at all times satisfactory conditions were present, yet continuous hourly sampling at the same site might reveal that from time to time runs of hours occured at very unsatisfactory levels which were wholly masked in the twenty-four hour mean. In such cases, without the more detailed sampling records, a correct assessment could not be made as to the presence or absence of conditions that needed further investigation.

Mr. T.L. Cooke (Manchester Area Council for Clean Air and Noise Control) addressed his remarks to Mr. Batho, to whom he made no apologies for raising an old chestnut, a matter he had rather expected Mr. Giblin of the S.S.F.F. to have mentioned earlier. He was concerned about the sales of coal from shops in smoke control areas which, as the law stood, did not offend the Clean Air Acts unless the shopkeeper actually delivered the fuel to the house where it was to be burned. Such sales were an embarrasment to the local authority and a source of resentment on the part of coal merchants' associations whose members might be, and were,

prosecuted if they offended in a similar way.

The shopkeepers' lobby pleaded the case of passing trade as a justification but, in his experience, such sales represented only a small percentage of the total coal sales.

It had been said that this was a matter which should be dealt with by prosecution of the offending householders. This was no easy matter, as the customers concerned were those who, in the main, were working during the day and burnt their smoky coal at night - and we had yet to devise a method of observing smoke emissions in the dark.

Professor R.S. Scorer (London Borough of Merton) said that Cllr. Biewer's advice to Mr. Batho, to instruct local authorities as to precisely what to do, was bad in principle, and sounded like a plea from someone who could not get his policy accepted by his local authority. He thought that this would be bad for democracy, and said that in his local authority what they resented more than anything about Mr. Heath's period as Prime Minister was the vast number of very precise instructions which had given local authorities no discretion.

As an educationist and socialist, he supported Mr. Mair's plea for less money for education and social services. He considered that in these spheres higher expenditure had been advanced too quickly. The cuts that now had to be made were not temporary, but only the beginning, and the country had to learn to live with less committed expenditure, otherwise there would be no money available for one-off programmes like clean air.

Prof. Scorer argued that the E.E.C. programme had been conceived in the balmy days before 1973 when there had seemed to be money for almost any exercise. That heyday was over, but the message did not seem to have penetrated Brussels yet. The E.E.C. air pollution control programme seemed to intend that no-one should ever have to cough, or that if they did, it was the government's fault, and never their own stupidity or incompetence. The extravagant monitoring and fancy regulations based on absurd theories had to be resisted.

It made him more chauvinistic than ever to think of the way progress was made without squabbles or court cases and with many good natured exchanges. He did not like to be told by people who did not know what a national survey was, what sort of survey to make, often in considerable and precise detail. There was no hope of ever achieving monitoring on the level now being thought up in Brussels, and it was not even desirable in the wealthiest of worlds. It could never come to pass in a large country such as France, where they would at least know about the intentions; in Italy they would not even admit to knowing those.

Cllr. D.F. Haynes (Mansfield B.C.) said that some comments had been made, particularly from the platform, in relation to smoke control and miners' concessionary coal. He would comment on concessionary coal because he happened to be a miner himself. On the question of smoke control, there had been a fair amount of criticism thrown at Mr. Batho, and Mr. Mair had not been mentioned. The Ministry had a job to do and he hoped they would listen to what had been said that afternoon in relation to cutbacks. He had a criticism of local authorities. It was all too easy for a local authority, when drawing up its budget for the next financial year, to make smoke control the Cinderella. That was how it had been for far too many years. It had been at the bottom of the list of priorities, whereas it should have been number one. On his Council, he fought like mad to have it called number one. At long last, the Council were getting somewhere, and had a progressive smoke control programme.

He wanted to argue the point with Dr. Parker on the question of concessionary coal. This was a myth! He suggested, respectfully, that it had been a number of years since Dr. Parker had been to Rotherham to talk to miners about solid smokeless fuel and the concessionary fuel itself. Negotiations were currently taking place between the NCB and the NUM with a view to drawing up a new national concessionary agreement, probably to come into operation by 1st January, 1977. And yet Mr. Mair in particular had suggested that perhaps concessionary coal should be replaced by a financial allocation. But it was not easy to get that kind of thing. At the same time Dr. Parker had said the miner at Rotherham had complained that the smokeless fuel concession given by the Board to the employees had been insufficient. Many bridges had been crossed since then. Should he talk to the miner now about his smokeless fuel allocation, it would be very different from what it had been years ago where he was having to pay out hand over fist like everybody else who did not work in the mining industry, in buying solid smokeless fuels. So it was a myth as far as this was concerned and the myth really came over because there had been a suggestion from Mr. Batho that there was not the co-operation from the miners and the NCB as far as smoke control areas were concerned. He wanted to tell Mr. Batho that in his particular area the NUM and the NCB bent over backwards to get stuck into smoke control areas. They were burning the bituminous coal but they were burning it on the Parkray Coalmaster. It was possible to go into those particular areas and breathe God's clean air. Where he lived, he overlooked a mining area which was not yet covered by smoke control and he could see the smoke lying right over the whole area. He pleaded that delegates should not keep bashing the Ministry, which had a job to do, and which had to look at the situation as it was at the time. But he hoped the Ministry at the same time would be sensible about this matter, and as far as he was concerned local authorities ought to be putting smoke control as the number one priority in the interest of peoples' health in the future.

Mr. J.B. Douglas (St. Helens M.D.C.) said that everyone seemed to agree that smoke control should continue, and were aware of the problems in the larger industrialised areas with dense populations. Those areas were often very well monitored and evidence was available of the progress made and the challenge for further improvements. Following Local Government Reorganisation, many such areas also found themselves with extended programmes.

He had just received confirmation of a large smoke control area with estimated gross costs of £330,000 and his Council fully supported the priority need for continued progress in that field. A number of other factors could be used to overcome some of the "misinterpretations" of the financial circulars referred to earlier, and those factors incorporated other advice from Government departments.

1. The expenditure of smoke control was being spent in the locality thus aiding the immediate economy.
2. The work provided by a continued programme was keeping a number of firms in full employment. To cut a programme could inevitably result in redundancies when fixers had been employed in a regular flow of work. The Direct Works Department was similarly affected.
3. A large part of the expenditure was used to purchase appliances, thus supporting the manufacturing industry in a time of recession.
4. The improved efficiency in modern appliances also helped the country's energy needs and supported the "Save It" campaign.
5. The future proposals anticipated in the EEC/WHO Directives mentioned by Mr. Batho, could also be added to those arguments.

A final point for future consideration of national policy was in the energy conservation field. It seemed unfair to the consumer that out of each £1 spent,

he should only get 30 to 38 pence worth of heat into his home from a solid fuel open fire. It was difficult and dangerous to get the fuel in the mines. There was, surely, a more efficient way of using it without such waste.

Mr. W.J.S. Batho replying to the discussion, said that there were one or two points to answer. There was a very general point in the first instance which had run through a lot of the discussion and which applied to things other than Smoke Control. It was a philosophical point about the relationship between central government and local authorities: whether the conference, as a meeting, or the NSCA as a Society, thought that it was right that local authorities should, as far as possible, make their own decisions about things which were going to be of chief concern to them locally. If we accepted that it was right that local authorities should do that, we had to accept the corollary that they should be allowed to make their own mistakes. It might appear to the National Society for Clean Air that a local authority was not pressing for smoke control in the way that the Society would wish that it would do. But it seemed to him infinitely preferable to having the Ministry say what had to be done. He knew what the Ministry was like because he was in the Ministry himself. He knew that it did not consist of people with alpha brains. They were not experts who knew everything about everything and who were going to come up with the right answer, and if the Society pressed for the Department of the Environment to tell members what to do, the Department of Environment would get it wrong. They would not get it wrong the whole time, but there would be many cases where, because direction came from the centre, not knowing the local situation, mistakes would be made. At some future meeting of the National Society, it could well be imagined that people would come to the rostrum and say how deplorable it was that local authorities who knew the score were not being allowed to make up their own minds.

Turning to the concern about references to smoke control in some circulars, he said that he was severely disappointed in local authorities if this kind of admonitory stuff in paragraph something or other, of circular something else, actually stopped them from doing things that they wanted to do. He felt that if a local authority was looking for an excuse it could find one excuse by blaming the Ministry. He supposed that this was fair enough. But if the authority was serious in wanting to do additional smoke control there was nothing in the circular to stop them, and no local authority had been refused grant by the Department. The Department of Environment had not turned down any applications. Returning to his earlier point, he explained that some ambiguity was inevitable in circulars on rate support grant since these covered a whole range of subjects. The preparation of the circulars took place in intimate consultation with the local authority representatives and he pleaded that when authorities got a circular of this sort from the Department, that they would at any rate do it the credit of reading between the lines. Ambiguity was the result of compromise which was inevitable when a circular of this kind was being drafted and there were strong competing interests. But local authorities were the ones who decided what was going to be done, and it was, he thought, shuffling off responsibility to say to the Department "oh you wrote this awful paragraph which might possibly have been construed as indicating that in certain circumstances...." He advised authorities to chuck it all away if they wanted to go ahead with a thing and if the Department of Environment did not positively tell them that they could not do it. It was the prerogative of local authorities to be able to say that they would go ahead and would implement smoke control, knowing of course that they would therefore not be able to do something else.

Referring to the question that had been raised once or twice about the need for direction and how to present points to local authority members, Mr. Batho said that the points that had got to be presented were quite simply that there was not going to be enough money for everything and, so far as the eye could see, it was going to be a question of local authorities making up their minds as to

whether they were going to have smoke control, or to have a leisure centre, or something else instead. This was the decision that had to be made and he thought that the responsible thing was to present the facts to the elected members who had to make up their minds and let them decide. Concluding that he had probably said enough about that subject, he said that he would go on with the discussion later if anyone wished to pursue it.

The next question he answered was the point made by Mr. Norton, about the increased cost limits. He pointed out that it was a terribly bad time, as people would realise, to go back to the Treasury saying that an increased cost limit was required, although he said these reviews had been made fairly regularly. He agreed that it was about time that another review took place. This was something which the Department would be undertaking. In parenthesis, he said that he was not sure whether he had been delighted or horrified to realise that the only thing that was going well was baby-cookers, but that perhaps they ordered these things differently where Mr. Norton came from.

Mr. Maxted and Mr. MacPherson had raised the question of the increased cost of solid smokeless fuel in comparison with the cost of bituminous coal. Mr. Batho remarked that this was a point which did crop up every now and again in correspondence received in the Department. It was something that needed to be looked at seriously. It was also necessary to look at the question of the distribution of stocks of smokeless fuels and in the light of the points made in that day's discussion, he proposed to ask the Clean Air Council to have a look at the whole question of the relative costs of different sorts of fuel and the problem of distribution, and to see whether anything could be done centrally by means of the Clean Air Council. In that respect he thought the discussion had been very valuable.

Mr. Cooke had raised the point about the sale of coal from shops. In reply, he said that this was something which, again, the Department needed to look at. He assured Mr. Cooke that his points had been noted and would be considered.

Another point that had cropped up once or twice was the question of monitoring and the costs of monitoring. This was something in which he thought an increase would have to be accepted, not only because of the EEC but also because Part IV of the Control of Pollution Act gave local authorities additional powers to obtain information about emissions into the atmosphere. Monitoring was a growth enterprise and he himself, in another capacity, was Chairman of the Monitoring Management Group in the Department. But he referred members of the Society to the excellent work done by Mrs. Weatherley of the Warren Spring Laboratory, in processing the National Survey Data. Warren Spring had most recently produced for the benefit of the Clean Air Council an extremely useful contour map showing the distribution of smoke and SO_2 over the country, and this was the sort of thing which would help central bodies such as the Clean Air Council to decide upon the sort of atmospheric pollution control that was going to be necessary in the context of the EEC Directives.

This led him on to the EEC Directives themselves. He had been interested to hear Professor Scorer's fulminations against the EEC but what was being dealt with at the moment were the first attempts at drafts and these drafts were, he hoped, going to be very considerably altered in the course of discussion. He could report to the Conference that the UK had a high reputation among other members of the EEC because of its effective control of atmospheric pollution. It was astonishing that the two basic images of London were still for so many people the idea of somebody groping his way through solid smoke or of Tower Bridge opening up. In the Department's propaganda they sought to get across to people on the Continent the notion that one could now see a mile and a half further than formerly, that there was now 70 percent more winter sunshine, etc; this sort of thing made a very real impact. It was these consequences of the measures that

had been brought about by the Clean Air Acts which had given the UK a position of very considerable authority in discussing atmospheric pollution matters in the EEC because we had faced the problem and dealt with it. This was going to stand us in good stead when we came to undertake the negotiations. We were going to be extremely tough in the negotiating and should not allow any old stuff to go through in the Directives. He said this with great confidence, since the leader of the UK Delegation to Brussels was in the audience and he hoped that at the end of it all, useful Directives were going to come out. Having made that chauvinist approach generally, he wished to make it clear that the UK was not always right - there was always the possibility that the Germans or the Italians might be able to do some things better than we could. The Brussels negotiations were going to be a two-way process. There were things we could learn from our partners, as well as things we could teach them. On of the things which he thought was going to come out was the notion of a framework around which our traditional use of BPM would be able to go on ahead.

The last point he answered was on concessionary coal. He found it agreeable to have an ally like Cllr. Haynes who was not in favour of bashing the Department of Environment, and thanked him very much for that. He had thought it was a very helpful contribution, and had been very glad to have the assurances which Cllr. Haynes had given to the conference, of the attitude that he and the NUM had taken towards concessionary coal. If he himself had given the impression through bad drafting that the NUM or the NCB were indeed half-hearted that certainly had not been the impression he had intended to give.

<u>Mr. L. Mair</u> replying to the discussion, said that many of his remarks would cover several speakers but that he had been very pleased to learn from Mr. Millington that they were on the same wavelength, and that Mr. Millington had referred to something that he had been thinking about for some time, that it was possible that it was a retrograde step when the principle of the black area had been abandoned. The black area had been an indication of a degree of priority, but Mr. Mair could not say that he was entirely at one with Mr. Millington, when he wished to put all the black areas in the Key Sector. It was a matter of whether you spent money from the Key Sector or from locally run schemes - it still had to be spent. He thought that the question of 'black areas' should be borne in mind when priorities were being assessed particularly as the Department of Environment wanted to express a view that action should be taken in some particular cases. Mr. Batho had referred to the circular in saying there was no reason why any authority who wanted to carry out smoke control should not carry it out. This was perfectly true. The trouble was that not many local authorities wanted to do it. There were a small number eager to do it, there were a small number doing nothing at all, there was a very large number in the middle who were just walking on the tight-rope, they could be pushed very easily one way or the other. In his own authority they would be making the last smoke control orders in December. The entire smoke control programme over the whole of the City would then be complete, and he thought Middlesborough and Hartlepool were in a similar situation. But there were other North Eastern Authorities where practically nothing was being done, but it was this majority, the substantial proportion of local authorities, who were just wavering, not knowing which way to jump. This was the devastating effect that the circular had had: they had been pushed into the side of doing nothing.

Councillor Biewer had asked the Ministry to direct local authorities to carry out smoke control but of course this was in conflict with Mr. Batho's idea that if we were going to sustain a democracy then local authorities should have complete freedom. This idea had not been prevalent in 1972 when certain named authorities had threats of compulsion thrust upon them. Mr. Sugden had said that freedom of choice was a reason for progress in Middlesborough. He presumed it had been the same reason for progress in Newcastle and Hartlepool

and elsewhere, wherever reasonable progress had been made. But this freedom of choice existed everywhere, it existed in the authorities adjoining Middlesborough, where nothing like the same progress had been made. Therefore he thought that the question of maintaining the status quo in order to ensure freedom of choice to ensure progress of smoke control did not hold water. He agreed with Mr. Giblin who had said that if we were going to have smoke control proceeding, it must be done as economically as possible. The most expensive items in smoke control were fire place conversions, and the fewer of those that were done, the cheaper it would be. He thought that either Mr. Sugden or he himself had been under a misapprehension when he had delivered his informal address in introducing his paper. He had not said that the North East wanted a special branch because of its situation in relation to the cost of conversions; what he had said was that the North East wanted to be considered as a special case in relation to circulars 171 and 88. If he had given any other impression he apologised to Mr. Sugden.

Mr. Maxted of Hull had emphasised the difficulty of enforcing the law in smoke control areas, because of the cost of solid smokeless fuels. This problem of course existed in all industrial areas, particularly mining areas, where Homefire and Rexco and Coalite were substantially dearer, weight for weight in relation to coal. He had wondered for a long long time why dirty air continued to be subsidised by selling coal at the present price. Why should not the cost of coal and the cost of solid smokeless fuel be rationalised, to take away the temptation to break the law by burning coal in smoke controlled areas? It would not cost anymore on the average, so why not subsidise solid smokeless fuel to enable to smoke control programmes to proceed. Several of the contributers had remarked about this cost of solid smokeless fuel.

He said that perhaps he had found difficulty in hearing Mr. Beagle of Hammersmith, because of the acoustics of the hall, when he had said that in Hammersmith the cost per head of smoke control had been £2.50 over a period of 18 years, it had seemed fantastically cheap to him. He did not know what the cost was in Newcastle upon Tyne, but he was afraid it was a very substantially greater figure than that; he had referred to some 40 or 50% of the open fires in Hammersmith having been converted to gas, or oil etc. quite voluntarily, but he was forgetting that they had been converted quite voluntarily because a grant had been available under the old system. But Mr. Sugden would argue of course, that so long as the grant ceased to be, then voluntary conversion to gas or electricity or oil would not continue. Mr. Mair had been very intrigued by Professor Garnett's reference to the monitoring of air pollution. Whilst a daily national average or a daily local average or a monthly average or an annual average were all being sought, averages did not mean anything at all. She was perfectly right, when she had said that it was the peaks that mattered. It was the old story of the man who had one foot in the fire and the other in the refrigerator. The average temperature of his feet was a comfortable 70°, therefore the average meant nothing at all in circumstances like that. It was the peak, the high temperature of the fire and the low temperature of the refrigerator, which was the real tally of things.

Concessionary coal had occupied much of the discussion and many opinions had been banded about. In Northumberland and Durham working miners got 8 tons 18 cwt of coal per annum, and when they went into smoke control areas they got 5 tons of Sunbrite or the equivalent value in other smokeless fuels. Retired miners and widows of miners got a correspondingly lower amount so that concessionary coal ought not now to present any real problem in pursuing smoke control.

SESSION 4

AIR POLLUTION CONTROL: THE RECOMMENDATIONS OF THE ROYAL COMMISSION
Sir Brian Flowers, FRS

Mr. W.F. Lester (Director of Scientific Services, Severn-Trent Water Authority) spoke about pollution control in the water industry and opened the discussion on Sir Brian Flowers' introduction to the 5th Report of the Royal Commission on the Environment.

Prior to the re-organisation of the water industry in 1974, there were 27 river authorities in England and Wales, about 1400 sewerage and sewage treatment authorities and 200 water authorities. Each had their own objectives, capital schemes and standards of maintenance and would do a job of work. They were generally rate supported. After the re-organisation there were 10 water authorities each of which was a water supply and sewerage and sewage treatment authority and which also controlled pollution, trade effluents, the quality of water in rivers and underground strata, their own sources of water for drinking water purposes and their own capital expenditure. Scotland was different, there were 7 river purification boards, the pollution control authorities, with the regional and island authorities responsible for water supply, sewerage and sewage treatment and land drainage.

It was intended to increase pollution control by the Control of Pollution Act, 1974. Part I dealt with waste disposal and all waste disposal sites would have to be licensed by June 1977. The water authorities would have the right to object if river or underground pollution would be caused by tipping, but the waste disposal authorities, the county councils, would be able to grant a licence subject to conditions if there were no objections. Part II of the Control of Pollution Act, 1974, if and when implemented, would effect most of the improvements proposed in the 5th Report of the Royal Commission. Dealing with but a few, Mr. Lester said it would adopt the open book approach to water pollution. Registers would be published with the quality of effluents achieved by regional water authorities and industries set against their consent conditions. This practice had already been started by some water authorities. The public, as distinct from the regional water authorities only, would be able to prosecute any discharger of an unsatisfactory effluent, using water authority data from the registers.

To some extent, this would offset the disadvantage of the pollution control powers being exercised by the same authority as was responsible for a large part of the river pollution in the form of discharges of treated sewage effluent.

Mr. Lester said his hope of a written paper for discussion was not to be. Indeed, had he re-read paragraph 269 of the Report he would have known that his earlier expectation of a paper for prior consideration would have been doomed to failure, since the Royal Commission failed to consult the water industry and the Waste Disposal Authority about water pollution control on the merits and difficulties of industrial and domestic waste disposal and their impact with ground and surface water pollution?

The Royal Commission had only taken the word of the Alkali Inspectorate and their atmospheric associates or effluvia producers, as to how good they were, how perfect was the law they administered and how effectively they had controlled atmospheric pollution from the scheduled works using the best practicable means approach; despite the hammering the Alkali Inspectorate took on the publication of their 110th Annual Report in September 1974.

Mr. Lester concentrated on generalities of the Report and especially on the

proposal for Her Majesty's Pollution Inspectorate (HMPI) giving the water industry's reaction.

The Commission had extended their terms of reference to concern themselves with the transferability of pollution between air, water and land Examples would be the washing of flue gases, water seeping through refuse tips, smoke from the incineration of refuse or sludge and the disposal to land of sewage sludge containing heavy metals. They had felt that there was insufficient co-operation between the controlling authorities and, as a remedy, proposed a new unified inspectorate to ensure an integrated approach to difficult industrial pollution problems at source whether these affect air, water or land.

He admitted that there had been instances of lack of co-operation, possibly due to the limited operational role of the Alkali Inspectorate. The water industry believed that the objectives of the Royal Commission could be achieved by improved co-operation between water authorities and the Alkali Inspectorate without the establishment of a new pollution inspectorate.

The Water Industry wished to emphasize that:

(a) It was vital to recognise that the Royal Commission were concerned with a situation which was now out of date. The water authorities created under the 1973 Act, armed with the powers of the 1974 Control of Pollution Act, would be in a stronger position to control water pollution and to develop existing links with the other authorities concerned where it was transferable to air and land. They were already co-operating with the waste disposal authorities (county councils in England and district councils in Wales) established under the 1974 Act and, when fully implemented, the main problem would not be the lack of powers but the lack of resources to implement those powers. To quote paragraph 65 of the Commission's Report, "the chief barrier to further progress is financial".

(b) The Royal Commission were impressed by the way in which the Alkali Inspectorate had been able to persuade industries to bring about improved standards of atmospheric pollution control. Mr. Lester said they would have been at least equally impressed by the improvements brought about in water pollution control had the Commission studied the work of the water authorities and their predecessors. The Rivers Medway and Eden in Kent and the Cole and Derwent in Warwickshire and Derbyshire respectively were used as sources of water for potable water supply purposes during the recent drought, whereas 20 years ago they were so polluted as to be unable to support fish life.

    It appeared to Mr. Lester than the Royal Commission did not appear to have appreciated the much greater extent of the operations of water authorities as compared with air pollution control. The Severn-Trent Authority had nearly 200 Inspectors backed by as many laboratory staff. There were possibly eight Alkali Inspectors in the area, graduate and post-graduate. The Severn-Trent staff outnumbered them 10-1 and a great number had the expertise to be involved, and were involved, in pollution control at the process level.

(c) Water Authorities had the duty to take account of the hydrological cycle as a whole; this enabled them, for example, to identify the areas in which pollution control would be most effective, environmentally and economically, taking into consideration a firm's water needs in conjunction with its effluent problems. In addition, water authorities had a statutory duty to supply wholesome water. These inter-relationships within the hydrological cycle were many times more common than pollution problems which could not be separated as between air, water and land.

(d) Mr. Lester thought the concept of 'best practicable means' meant all things to all men. It had already been tried in the context of water pollution control, being the chosen technique for control of industrial effluents in the Rivers Pollution Prevention Act 1876. It had subsequently been overtaken by the more flexible approach in the Rivers (Prevention of Pollution) Acts 1951 to 1961, which had proved far more effective. However, the real problem with this concept was its ambiguity. The implication of the phrase was that all plants should adopt the most effective method of reducing pollution, thereby achieving uniformly high emission standards, regardless of the receiving capacity of the local environment. This was alien to present DOE philosophy in the EEC (which the water industry supported). The alternative interpretation that 'best practicable means' required the balancing of costs and benefits to determine the appropriate expenditure in individual circumstances had long been employed by water authorities and their predecessors, but hardly appeared consistent with the phrase. Water authorities were concerned with protecting rivers for identifiable in situ and external uses, which was a more economic approach than uniform emission standards. It was not necessarily less stringent in every case; in some cases the 'best practicable means' was inadequate in that there had to be a total ban on some effluents, for example the discharge of pharmaceutical wastes containing harmful non biodegradeable compounds to potable water supply rivers.

(e) The water industry accepted the premise that it was essential to look at the effect of pollution on the environment as a whole. The very few problems which had arisen in the past had not given rise to much detailed consultation with the Alkali Inspectorate over flue gas washing and similar processes. For the future, water authorities would be glad to take part in the full examination of the options available between the parties involved.

(f) Speaking directly to the concept of HMPI, he said the water industry were concerned to understand how the Secretary of State could act as the 'court of appeal' on discharge consent standards and waste disposal licences if there was also a unified pollution inspectorate within his Department. In the relatively simple context of balancing the interests of solid waste disposal and water pollution, the Department had recently said "It is hoped that close collaboration between waste disposal authorities and water authorities will avoid unnecessary appeals to the Secretary of State on the implementation of the Act."

The water industry agreed that, in some cases, there was a need for a co-ordinated approach to the control of industrial pollution. At present water authorities and waste disposal authorities were answerable to the Secretary of State for the Environment, who was also responsible for the monitoring activities of the Central Unit on Environmental Pollution, and the water industry agreed the first essential was to transfer the Alkali Inspectorate back to the DOE. Control over the local and regional bodies with executive powers, i.e. water authorities and waste disposal authorities, would remain as it was at present, within the appellate control of the DOE. As a result, the Alkali Inspectorate, the waste disposal authorities and the water authorities would be left to deal with the industrial pollution of air, land and water, respectively. Each would have its own experts in its particular field, able to work out an integrated approach to pollution in its particular field, able to work out an integrated approach to pollution control at local level. The three sectors would be within the overall control of the DOE and by the exercise of their appellate functions they could ensure that the objectives of the 5th Report of the Royal Commission on Environmental Pollution were achieved.

The water industry believed that the achievement of the 'best practicable environmental option', a persuasive political phrase if ever there was one,

would depend on early collaboration at local level between industry and the regulatory authorities, whether a change in production was planned or an entirely new works proposed.

Mr. J. Norton (Leeds M.D.C.) said the Alkali Inspectorate should be an advisory body regionally based, to give advice to local authorities. They should liaise with industry to agree 'target' figures for air quality and should be financed by the joint local authorities and industry.

Local Authority Environmental Health Officers should be supported by suitably qualified staff in their departments and be the officers directly in control of local pollution from all works in their area. Such arrangements would, he felt, allow Local Authority staff to have continued confidence in their future and the future of new entrants to the field of environmental health.

Mr. Norton thought that if the money required for setting up an HMPI were injected into local government that would permit the employment of suitably qualified staff in Local Authority departments (i.e. industrial chemists, combustion engineers, acousticians) to support Environmental Health Officers.

Mr. G.R. Millington (Wakefield M.D.C.) felt there was much good sense contained in the 5th Report. He agreed with the recommendation that the Alkali Inspectorate should return to the Department of the Environment, but expressed concern that the situation could again be reversed in years to come.

He did not approve of the unified Inspectorate and suspected that neither would many local government officers, especially those with long experience in pollution control. He questioned the purpose of HMPI taking over the existing staff and responsibilities of the Alkali Inspectorate, and whether the country could afford it.

Local Authorities had recently been re-organised and Mr. Millington felt that they should not have to go through another upheaval so soon.

Mr. Millington wondered if the Royal Commission had asked the Alkali Inspectorate, who would form the nucleus of HMPI, how much they knew about noise since, in his experience, while they were good chemists, they were by no means acousticians. The newly-formed Local Authorities were becoming geared-up to administering new legislation and this should be emphasised.

Mr. D.G. Hearn (The Associated Octel Co. Ltd.) said it would help the control of the environment if the organisation of the Inspectorates had regard for the total task of chemical plant management. Experience led him to believe that the best results were achieved when dealing with the fewest number of Inspectorates.

He put forward four points against some of the Royal Commission's recommendations:

1. The amalgamation, following the Robens Report, into the H&SE of many Inspectorates had been a good step towards reducing the number of Inspectorates. It was inadvisable to reverse that programme. There were particular reasons for the Alkali Inspectorate being within the H&SE:

   - The H&SE was becoming more concerned about the effect of industry on its surroundings and they needed the Alkali Inspectorate's knowledge about spread of gases and particulates. Also the H&SE had to study the spread of gases and particulates within the working place as caused by emissions from stacks and equipment. The data possessed by the Alkali Inspectorate was useful to this.

- An important feature of assessing best practicable means for control of emissions concerned reliability of equipment. The H&SE was accumulating that data and the Alkali Inspectorate should be served by it.

- Industry had difficult times dealing with planning authorities and vice versa. Both would be better served by being able to turn to an H&SE made the more authoritative by having the Alkali Inspectorate within it.

- With the Alkali Inspectorate within it, the H&SE would be a more credible spokesman to the public about the surveillance of emissions hazards and toxic risks from major plants. This would be less confusing than having it spread between H&SE, Alkali Inspectorate and Local Authority.

2. It was wrong to advocate the handing over of surveillance of registered processes when emission controls and best practicable means for that process had been agreed. The Royal Commission proposed such a handover from Alkali Inspecorate to Local Authority.

   It was better for the Alkali Inspectorate to continue with the surveillance and use what was seen of better control performances to help the lesser performers.

   Furthermore, the means of achieving control of emissions could improve or be replaced by cheaper means. The Alkali Inspectorate should continue with its surveillance therefore so as to share in industry's innovation of these and so be ready to define the improved best practicable means of the future.

3. It was better to leave the structure of surveillance as it was than to form the new bureaucracy of HMPI. In particular there was no balance of advantages in the proposal to take setting of consent conditions away from the Water Authorities. Before any change was made, the value of the present system should be realised. The Chemical Industry respected the fact that the RWAs had knowledge and control of the whole water cycle in their region. It was sensible that they, having that total responsibility, should set consent conditions. Industry could respect, therefore, discussions with those authorities about the consents, means of achieving them, and performance.

4. It would be wrong to allow changes to be based on the case that emission controls needed a special government organisation when more than one receiving media was affected. Experience of this did not justify it. The Associated Octel Co. Ltd. operated 60 controls on various discharges and only six of those involved a discharge to another media. In each of those six cases their nature limited the options and no different bureaucracy would have aided the solution to the problem.

Mr. Hearn fel that, all in all, the Royal Commission's recommendations would not result in as great an improvement in the control of the environment as would a consolidation of the present systems. The new form of bureaucracy would not be consistent with his views of what would be helpful to the chemical industry.

Mr. Byrom Lees (Fuel Technology Consultant) supported the continuation of the use of BPM, providing that the 'best' was equal to or better than the standards adopted in Europe. This was, unfortunately, not the case regarding the emission of unburnt solids from small and large oil-fired plants. Boilers with evaporation less than 40,000 lb/h could emit up to 0.4% by weight of fuel and large boilers greater than 475,000 lb/h could emit up to 0.2% by weight of fuel consumed. In Europe the standard in some countries, notably France and Germany, was less than half that level.

Smoking from oil-fired boilers could be and had been readily eliminated. The bulk of the emission to which he referred consisted of particles between 5 and 100 microns, dust particles not visible as a plume.

Referring to the smaller plants generally installed in urban areas and which operated with chimneys less than 50 metres high, a high proportion of the emission fell locally. The quantity emitted from oil-fired boilers with an output of 30,000 could be of the order of $\frac{1}{4}$ - $\frac{1}{2}$ tonne per week of acidic dust most of which would fall within the urban area.

Dust collecting plant had been designed to reduce the emission below the accepted Continental Standards. No modern commercial and industrial oil-fired plant should be installed without simple, but adequate, dust arrestors.

Another factor should be taken into consideration. In England, engineers had adopted the "best practicable means" in the car industry and the ship building industry, with lower standards than those used abroad. As a result many people today owned foreign cars because they were considered more reliable and more efficient. Everybody used gasoline and liquid fuels derived from crude oil imported in Japanese-built ships. Our boiler plant and other oil-fired plant manufacturers had to be competitive with foreign plant manufacturers and use standards equal to, if not better than, our competitors if they wished to maintain their export business. Our urban areas should be as clean, if not cleaner and healthier, than corresponding foreign towns and cities. We had to make sure that we adopted "best practicable means" and when we said "best" that did not mean "second best".

Mr. A.G. Shankster (Stockton on Tees B.C.) said he had recently been asked by a Government Body to take noise measurements within the Borough, as there was no equipment available, and no justification for the expenditure since measurements were only undertaken once or twice per year. He could forsee that that would be the case if HMPI were only to deal with flare stack noise. H.M.F.I. at present dealt with noise inside factories and local authorities dealt with external noise. To add a third party would only lead to duplication, overlapping and the formation of 'grey' areas.

The guidelines which had been mentioned ought to be published or otherwise made available to local authorities. Mr. Hearn had mentioned that "Emission control problems should not be handed over to local authorities", but Mr. Shankster submitted that if guidelines were readily available, and not kept solely within the Inspectorates, then the enhanced co-operation and knowledge would allow local authorities to undertake further duties more readily and operate as the Royal Commission wished, as the eyes and ears of the Inspectorate and the body to whom the public could turn for assistance when they needed it.

Mr. R. Kidd (Newtown Abbey D.C.) asked whether economic consideration outweighed the clean air considerations with central government. He did not think this was the case with the Inspectorate. In view of what had been said that morning about the problems of atomic waste and that local authorities should be more responsible for it, Mr. Kidd asked how local authorities could be more responsible for the discharge of atomic waste, in view of the fact that, in his opinion, economic considerations outweighed the clean air considerations in all areas.

Mr. D. Hinchliff (Chief Alkali & Radiochemical Inspector, D.O.E., Northern Ireland) said that his reason for coming to the platform was to make an observation rather than to ask a question. He had no particular axe to grind about the Royal Commission Report because, the Health and Safety at Work Act 1974 did not extend to Northern Ireland, although an abridged version was on its way. The Department of Environment for Northern Ireland had, however, rejected Section 5 dealing with emissions to air. Consequently his Inspectorate, which dealt with alkali, radiochemical and other pollution problems and which, like the Scottish Inspectorate, was really a miniature HMPI, continue to operate within the Department of Environment and not the equivalent of the Health and Safety Executive.

Mr. Lester had given his reasons for rejecting the recommendations made in relation to the formation of a unified Inspectorate and, to a certain extent, his comments seemed to echo the views of some waste disposal authorities. Mr. Hinchliff suggested that there had possibly been either a misinterpretation or a misunderstanding by those authorities of the recommendations made in the 5th Report with respect to entry into works by Inspectors of the proposed HMPI. He thought that these authorities were under the impression that the creation of an HMPI would adversely affect their operations and, in his opinion, that was a complete misconception. The aim of HMPI would be to enter a works, look at a particular process which was causing a pollution problem, solve if possible or at least minimise pollution which occurred from that particular process at source, recommending recycling techniques within the works, re-distillation, etc. They would not be directly concerned with standards associated with the ultimate disposal of liquid or solid waste which would remain within the control of the existing regulatory authorities.

Mr. A.H. Brown (Health and Safety Executive) had spent the last five years of his seventeen years as an Alkali Inspector in a District which had not been visited by the Royal Commission. The previous twelve years he had spent in Bristol. On page 138 of the Royal Commission's Report, specific mention was made of the close working relationship which existed between the inspectorate and the new Bristol City Council. In his experience similar close relationships would be found all over the South West and also in his present District. With experience covering roughly a quarter of England he had yet to meet an Environmental Health Officer who resented the operations of the H&SE and wished to take over their duties. He wondered from where the apparent pressure for Local Authorities to take over control of registered works emission had come.

In his experience as an Alkali Inspector, it had always been an instruction that complainants should be visited if at all possible and that they should be visited rapidly. Similarly, it had been an instruction to visit Environmental Health Officers regularly, and the H&SE were encouraged to attend meetings of Environmental Health Committees. He therefore, took issue with Sir Brian's suggestion that the H&SE treated the public as an 'ignorable nuisance'.

He then referred to Mr. Lester's remark that from 1876 to 1951 when 'Best Practicable Means' applied to liquid effluents, water quality had deteriorated. Mr. Brown said raw sewage was being discharged to waterways at that time and no-one could seriously suggest this was BPM. He suggested that what Mr. Lester objected to was not the concept of BPM but to the administration which failed to achieve BPM in the water field.

Miss Fiona Riddoch (Friends of the Earth) said that while talking about the transferability of pollutants, Sir Brian Flowers had cited radioactive wastes as a difficult area, and had later mentioned the need for more public accountability in the whole environmental sphere. She asked if Sir Brian could comment on the proposals to extend the reprocessing plant at Windscale and the way it had been dealt with by industries, by BNFM, and the Cumbrian Local Authority.

Miss Mary McClintock (The General Public) asked that if, as Sir Brian had suggested, one should look at the whole industrial process, one should surely consider whether the needs of society that industry proposed to supply justified the means of production. If we did not require further electricity generating capacity, did the production of unmanageable radioactive waste from nuclear power stations justify the proposed developments of the nuclear power programme, when other methods provided better practical environmental options. As she had not read the Royal Commission's 6th Report, she asked Sir Brian Flowers to clarify their view of 'needs' versus 'means'.

Sir Brian Flowers replied that his purpose that day was essentially to discuss the 5th Report. The issues of nuclear power which had been raised in the 6th Report had, probably, been read by very few of those present and he considered that no useful purpose would be served were he to comment on one or two particular issues. The proposed extension of the Windscale plant was a particular issue which came under planning investigation at the present time and was, so to speak, sub judice.

Mr. T.H. Iddison (Dartford D.C.) said that he wished to confine his comments to one point that had been raised in the course of discussion, namely the relationship between Local Authority officers and the Alkali Inspectorate in relation to registered processes. Mr. Millington had said that he did not want to be a Deputy to the Alkali Inspectorate. He also appeared to imply that it was only very recently that a good relationship had been established between the Alkali Inspectors and Local Authority officers. Mr. Hearn was opposed to best practicable means being enforced by anyone other than the controlling body. Having spent more than 40 years in office in a cement producing area, his experience had been that the Local Authorities were concerned at the lack of information and their inability to become involved in relation to emissions from registered processes. It was clear that District Councils were not likely to be made responsible for the control of registered processes but the proposals set out in the Royal Commission's Report would enable joint inspections to be made with the Alkali Inspectorate. It would be naive to think that once the terms of best practicable means had been laid down by the Alkali Inspectorate, they would automatically be met by industry. The involvement of Environmental Health Officers would enable them to carry out inspections and to notify the Alkali Inspectorate of any infringement of best practicable means. He would not be averse to co-operating with the Alkali Inspectorate on this basis.

Insofar as co-operation between the Alkali Inspectorate and District Councils was concerned, this had been established many years ago by Dr. Carter, when he was Chief Alkali Inspector. He had instructed his District Inspectors to make frequent calls upon local authority officers and this policy had been followed since that time.

Cllr. H. Walker (Nottinghamshire C.C.) said that his aread, Eastwood, Nottinghamshire, had problems mainly on account of open tipping, of waste disposal within close proximity to owners' properties. Did Sir Brian think that Government grants should be made available in order for the generalisation of incineration, and would this eliminate the health hazard?

Mr. H.I. Fuller (Institute of Petroleum) remarked that an industry was part of a locality which interacted with the local community, and needed to maintain close links with the Local Authority representing the local community. Only in this way could a works fully understand its local "environment" in the widest sense.

The oil industry tried to achieve environmentally sound operation for its plant by the application of best practicable means adapted to the needs of the local situation. They valued the help of the Alkali Inspectorate, who visited many works and had wide experience. The oil industry's relationship with the Regional Water Authorities, the Waste Disposal Authorities, the Alkali Inspectorate and the Local Authorities had to be frank and close if problems were to be understood and solved in the light of B.P.M.

The Royal Commission was very concerned about interactions between disposal options, but Mr. Fuller wondered if they were so frequent or so severe in practice. Certainly one had to consider that alternative disposal of, say, a liquid effluent would give rise to an air pollution problem or of solid waste

disposal, but these problems surely not so big that they would justify setting up a whole new Inspectorate? He suggested that the proper role for a new body would be advisory - to help in the development of national guidelines or criteria and for the exchange of expertise. The existing authorities should do the controlling in the light of local circumstances.

Mr. D.L. Mathur (Fellow of the World Health Organisation) reported that in India, where the deterioration of the physical environment was not so great as in the case of more developed countries, the problem of environmental pollution was being approached in its totality and not in fragmentation. They were working on the philosophy that the preventive measures for the control of pollution should be taken at the planning stage of industrial estates and complexes, thereby ensuring that there were no subsequent problems.

The problem of the prevention and control of environmental pollution could be easily and better tackled if there was an integrated agency for the following reasons. First, very often a problem of air pollution could be converted into a problem of water pollution, as in the case of gas cleaning. Such a situation could be effectively tackled if there was an integrated agency which could co-ordinate the work of both units.

Second, this would also help in devising B.P.M. for industry. Thirdly, in developing countries, it could reduce the financial burden by halving the staff requirement, and the amount of equipment.

This idea was gaining ground in India for the constitution of unified agencies for the control of air, water and land pollution.

Sir Brian Flowers commented that the purpose of a Royal Commission was, of course, to generate discussion, and that purpose had certainly been achieved. Several people had implied that the Royal Commission in its work had taken too much notice of the Alkali Inspectorate. He did not think that was true at all. The Commission had consulted many local authorities, made many visits to local industries, and seen local residents and local councillors, all of whom, in their time and in their different ways had made great contributions to air pollution control in their areas and had made contributions to the Report. The Commission had implied in the Report that if relations between the Alkali Inspectorate and the local Environmental Health Officers throughout the country were as good as they were in Bristol, there might have been no need for the Report. But if those good relations relied simply upon personal friendships and contacts, that was not sufficient to ensure that one had proper control over the environment. When national and local issues conflicted, there had to be some kind of system that went further than mere personal relationships, however important they were.

Referring to the remark that environmental health officers would be deputies to the dreaded Alkali Inspector, or the HMPI Inspector, Sir Brian emphasised that this suggestion was, of course, only in respect of scheduled works which were the responsibility of the Alkali Inspector. And so the local E.H.O. either had no role whatever, as at present, or he was brought in by the Alkali Inspector to help him in controlling those scheduled works. For non-scheduled works the environmental health officer was supreme, and maybe even the Alkali Inspector had to do what he was told in those cases. He agreed with Mr. Iddison that local authorities were needed to see that B.P.M. was actually achieved in practice from scheduled works. The Alkali Inspector could not be there all the time. But the environmental Health Officers could, and that was why the Report said that he should be keeping an eye on things in practice. He also agreed with Mr. Fuller that the expertise of the Alkali Inspector was needed so that knowledge and practice of a particular plant could be carried to other parts of

the country, perhaps to other kinds of plant. We needed that high-level experience which travelled around the country, so to speak.

Several people had suggested that the principle of the transferability of pollution was not a general problem. Sir Brian had already given his views that it was a general problem. It was not recognised as such simply because it was not looked at and simply because if a particular industrial process was going alright, there may be only one major form of pollutant from that, and one did not have to think about other forms of pollution. But if, for some reason one was forced to increase the standards to be imposed on that particular process one might find it better to change the form of pollution produced, resulting in the problem of transferability. That matter was being studied by the Department of Environment who were consulting all the people whom the Royal Commission should have consulted if they had had the time.

It had been said that what the Commission proposed in HMPI was a complete new reorganisation after everything had just been reorganised. Sir Brian replied that they had not suggested a reorganisation of anything. They had only suggested that the responsibilities of the Alkali Inspectorate for looking after the arisings of air pollution from scheduled works should be extended to cover difficult industrial processes involving pollution in other fields. The Commission had described HMPI's duties and responsibilities in such a way that he could not see how it could possibly have made clearer that it was not intended to encroach upon the statutory responsibilities of the waste and the water authorities, or to do so in the future, unless, of course, in the future, everybody agreed that that was desirable after all.

There had also been suggestions that, rather than create HMPI, the Alkali Inspectorate should remain with the Health and Safety Executive rather than return to the Department of Environment, even though the Alkali Inspectorate existed to look after the general air environment, and even though the Department of Environment existed to look after the environment more generally still. This matter was argued quite forceably, as one or two of his colleagues in the audience who were members of the Commission would confirm. The whole problem was, how did one make the Health & Safety Executive, which was an industrially oriented body, responsive to the environment generally and the public generally, when it was a body set up to look after health and safety at work? Looking after the environment in general was a different problem with different criteria to be applied to it. And if one said that air pollution arising from industrial plant should be looked after by the Health and Safety Executive, however wrong Sir Brian thought that might be, then why should not the water and waste pollution arising from those plants come under the Health and Safety Executive also? Was one suggesting that the water and waste authorities should also come under the Health and Safety Executive, at least, insofar as difficult processes were concerned? It should be remembered that the Health and Safety Executive was not confined to difficult industrial processes. Sir Brian thought that really <u>would</u> interfere with the present system. That really <u>would</u> encroach upon the statutory responsibilities of the water and the waste authorities. Mr. Hearn had said that he wanted only one Inspectorate, and so had argued for the AI to stay in the Health and Safety Executive. But then he had argued that the responsibilities for water should remain separate. The Commission had been through all those arguments, too, and they had tried to follow the logic of how industrial pollution arises. Furthermore, he considered that if, as we suggested, the responsibility for scheduled works should remain with the Alkali Inspectorate, or HMPI once it had been given to them, then the Inspectorate would inevitably grow and grow as it took on more scheduled works. That, again, would encroach upon the ability of local authorities to look after local affairs. The Commission had said that once the great expertise of HMPI, (higher expertise, it was hoped, than the AI had at present) had been brought in and had satisfactorily solved the problem, at least for the time being, then it was better to hand back as much of the control as possible to the local authorities, and as soon as possible.

Since there clearly remained some confusion over this, Sir Brian reiterated that the Commission did not recommend the practice of best practicable means on water quality, or on any other environmental quality. They recommended the best practicable means on the industrial arisings, on the process that gives rise to pollution, in whatever form. They had said that BPM should be used to meet the desired qualities laid down by bodies other than the Inspectorate - laid down by the water authorities, the waste disposal authorities, or the Department of Environment.

Sir Brian felt that it was perhaps appropriate to say in Auld Reekie, that HMPI was essentially a Scottish industrial pollution inspectorate writ large. The Scots were so often ahead of the rest of the UK and he hoped for England's sake, and also for Wales, since he had been brought up there, that there would be no devolution for everyone's sake!

Mr. W.F. Lester commented on the Best Practicable Means and on the remarks made by Messrs. Hinchliff, Hearn and Iddison. He understood that the best practicable means applied to reducing the arisings of pollution from industrial processes. But, time and time again, Inspectors were sent into factories, achieving a 50% saving of water, a change of the process, a saving of 50-80% in the pollution load, but unless control was exercised by putting standards on the discharge, and enforcing the standards, the factory management soon allowed things to slip back to the original situation, and all the work that had been undertaken came to nothing.

Mr. Lester then considered the best practicable means approach as applied to sewage effluents discharging to rivers. They could be treated to very high standards indeed, and if the best practicable means approach was applied to all sewage effluents it would put immediately 20-30% on the charges one had to pay for sewage treatment. He thought Mr. Hearn's comment very relevant for he had already achieved the best practicable means from a particular process and was already thinking towards the next improvement that would have to follow the discovery of an improved best practicable means. In Mr. Lester's view, one had to be in a situation where, if the objectives of pollution control were being achieved, then there should not necessarily be a tightening of the standards, merely because some new technology came along which produced a better best practicable means.

Mr. Lees had argued that he agreed with BPM, provided that it produced standards better than the EEC. The EEC directed that there should be fixed emission standards in water supply and river pollution, but many people knew that the Italians and the French had little intention of achieving those standards, and the U.K. were just being lumbered with the standards, which we would do our best to achieve. The other approach of achieving the water quality objectives and determining each standard according to the requirements of the situation was certainly a more economic and more environmentally responsible approach.

In Mr. Lester's opinion, the only circumstance when the best practicable means should be considered was where technology would not yet produce the standards required by the environment.

He agreed with Mr. Brown's comments on the quality of river water when it was fouled with untreated discharges of sewage, that was not the best practicable means approach. In his view it came back to control again, and unless there was a control organisation to ensure that standards were achieved, no real progress would be made.

He said he could not possibly disagree with the Chairman's summing up, though he felt it should be on the record that he did not hold with the views Sir Brian Flowers had expressed.

SESSION 5

PEOPLE, POLLUTION AND RETRIBUTION
Professor G.M. Howe

RURAL POLLUTION - THE HIGH PEAK, DERBYSHIRE
I. Holmes

Mr. J.T. Hague (West Derbyshire DC) opening the discussion said that he wanted first to thank the Society for the opportunity to speak. He was sure that the audience would agree that the two papers given had been both interesting and enlightening.

Remarking that on the first page of Professor Howe's paper he had made reference to the debt owed to Edwin Chadwick, Smith, Neil Arnott, J.P. Kay, John Snow and John Simon for promoting sanitary reform, he wondered whether or not Professor Howe would like to comment on Snow's performance for England as well! When he had read the paper, his first reaction had been that it would be better to stay indoors. When primitive man had lived in small numbers, he had little adverse effect on his environment. His sewage could be harmlessly absorbed by the rivers, his smoke had soon disappeared into the atmosphere. It was only when the population had grown and when man had come to live in cities that his wastes had begun to make their impact by poisoning the water and the air. Then industrial development had taken place, restricted mainly to the developed countries. Obviously, more people and more industry would pose more problems of disposal and pollution. He asked Professor Howe whether he had a grave fear that we might not be able to contain our pollution.

Professor Howe had not drawn attention to pollution from the car industry. Regarding lead as an air pollutant emitted from cars, Mr. Hague said that traffic policemen in the USA had been found to have high levels of lead in their blood. He wondered whether lead as an additive should be removed from petrol, provided that it was not replaced by something more dangerous. Could the day arise when the British Bobby on point duty would be wearing breathing apparatus like his Tokyo counterpart?

He asked whether Professor Howe was aware of the controversy concerning SO_2, generated in England and allegedly falling out over Scandinavia, which had apparently altered the pH of the soil and was killing off trees. Could he elaborate on this and had he any comments to make concerning air pollution being transported to another country by natural ventilation means?

He agreed with Professor Howe's comments in relation to Housing and said he knew from working in a large city that the demolition of rows of terraced-type houses with four houses in a yard and the transfer of the inhabitants into high-storey flats had resulted in a loss of community spirit and had given the inhabitants a feeling of isolation.

He remarked that most of our systems were flexible, giving public authorities wide areas of discretion; river authorities exercised discretion in granting consents, Alkali Inspectors had some discretion in what they would require as provisional best practicable means, many sea fisheries committees had bye-laws which had areas of discretion, and so on. In exercising those discretions he would wish the authorities concerned to attempt a balance between the interests of those members of the public who stood to be affected by pollution and the interests of the industry, remembering that a viable industry was a matter of public interest also. He asked Professor Howe whether he felt we had the correct balance in that respect.

He had been interested to read the paragraph relating to noise but said he would be grateful if Professor Howe would elaborate on the groups of people he had mentioned that were sensitive to low frequency vibration. He wished to comment on planning with regard to pollution control. There was no doubt in his mind, and it had been mentioned on previous days during the conference, that good planning could prevent or reduce the ill effects of pollution. Sources of noise could be moved away from centres of pollution, or could be shielded, factories could be sited where their effect was minimised. He wondered if Professor Howe thought that local government reorganisation had been beneficial in that respect.

Turning to Mr. Holmes' paper, he had noticed in the first paragraph that High Peak DC received £750,000 in the form of rates and he wondered if Mr. Holmes could explain how much of this was spent on Pollution Control.

One of the slides had shown a man on a rope releasing dangerous overhanging rocks; he would have thought that method a hazardous occupation. In fact he had been surprised that Mr. Holmes had not shown a slide of a dropped ball technique. In his own authority this had been overcome by drilling from above at a 15^{o} angle to three feet below the quarry floor, which ensured a clean break.

He was particularly interested in windwhip since his authority, adjacent to High Peak, had a village situated just over a hill from the three quarries in the Borough of High Peak. Initially one of those quarries had increased its output to such an extent, still using existing dust suppression equipment, that the village had become literally smothered in dust fall-out. Considerable progress had been made and he added that the liaison committee mentioned by Mr. Holmes, and which he himself attended, had made great strides in public relationship between the quarries and the people affected and the Borough were to be congratulated on its formation.

He had been pleased to see the slides showing the grassing of quarry floors which he hoped would become normal practice. One slide had shown an inversion in a valley and he did not think that any mention had been made of this inversion in the paper. He asked whether Mr. Holmes would like to elaborate on this point.

Mr. Holmes had mentioned weight restrictions on traffic routes; those routes had been specifically built for quarry traffic and travel though his own area; he felt also that a mention should be made of wheel washing with which the quarries in his area had been installed.

There had been a slide of Glossop, he believed, which had shown houses on the side of a valley and it had appeared that those houses had been built above a chimney stack in the centre of the town, which seemed to be a lack of foresight in planning. He wondered if this was the case Mr. Holmes had mentioned, of bad planning decisions by the former authority. He asked Mr. Holmes to elaborate on co-operative management in relation to planning and how it worked between the departments concerned.

He commented that in Derbyshire there were many disused quarry holes that had been used in the past for infill for refuse disposal. The problem now was that the water authority would not allow these quarry holes to be filled in with refuse due to possible pollution. He asked whether Mr. Holmes knew of any solution to this problem.

Mr. Hague concluded by mentioning that in his authority, they had Blasting Committees in the villages near to quarries. The reason for that was that they had three quarries in a dale in different ownerships and the council had kept receiving noise complaints from the villagers. With the formation of those committees, the Quarry Manager concerned phoned a committee member ten minutes

before a blast. In any complaints were received they could then be traced back to the quarry concerned and the face, the amount of explosives used, the weather conditions etc. could be ascertained. It was interesting to note that since those committees had been formed fourteen months previously, no complaints had been received.

He was sure that, having listened to the two speakers, the audience would agree with him that the NSCA as a society held a responsibility in the control of pollution and he trusted that the papers would stimulate a worthwhile discussion.

Mr. F.H. Free (Huntingdon DC) said that at the 42nd conference of the NSCA a member had voiced the opinion that the papers given were so technical as to be incomprehensible to the majority of the lay members and that this factor would have to be considered in the decision on whether local authorities should be represented by their members at future conferences. Members at the present conference would have appreciated the readily understandable papers put with such clarity.

Professor Howe in "People, Pollution and Retribution" had summarised the environmental factors relating to pollution which give rise to maladjustment or disease. To a society whose principal aim had been the improvement of the quality of the air we breathed it was perhaps a timely reminder that there were other facets which were being constantly investigated and monitored and which occupied the minds and employed the talents of many of its members.

Professor Howe's first paragraph, under the heading 'Atmosphere' had queried the assessment of excess deaths following certain pollution episodes. Mr. Free put it to him that elderly people were more susceptible to many things, in particular to accidents which resulted in death. Death might be due to multiple injuries but the cause was surely the vehicle which struck the victim down - or was that, he asked, too simple?

It did us no harm to be reminded that the smoke we saw was not the only nor necessarily the greatest danger and that there had been little research into other atmospheric pollutants, such as lead, cadmium, beryllium, asbestos, etc. except in the vicinity of the pollution source. We had to ask, however, what benefits there might be in expensive research further away from the source of the pollutants.

Leaving the question of air pollution Professor Howe had dwelt briefly on water, food and land pollution before moving on to housing occupational hazards and noise - all of which were of import to members, if not directly of importance to the Society.

Noise was often considered to be a pollutant of the atmosphere although some would doubt its relevance in the context of clean air, notwithstanding the subject of the proposed spring seminar. In this section of his paper Professor Howe had mentioned a correlationship between ambient noise levels and admission rates to a psychiatric hospital and of evidence relating to illness which had been presented at a meeting of the Institute of Biology. He had himself been particularly interested also in the comment regarding types of building relating to the expression 'intolerable harm'. He had no doubt that members would like to hear Professor Howe enlarge on those and many other matters.

Turning to consideration of Mr. Holmes' paper, Mr. Free said that it was entitled "Rural Pollution - the High Peak, Derbyshire" and whilst it dealt most excellently and expertly with the problems relating to quarry work in his area it also referred to other aspects of rural pollution. The quarrying aspect had been covered by the previous speaker but he felt constrained to refer to the

report on the results of research carried out by the quarrying industry into the reduction of noise and the eradication of smoke and dust and the comments on the open tipping of arrested dust and its subsequent dispersal into the atmosphere. An industry which appeared to be so forward thinking should surely not be deterred from carrying its research to its logical conclusion, or was there no profit - monetary or otherwise - in such action?

He wanted to refer to some of the other causes of rural pollution. Raw materials were more often to be found beneath our green and golden acres than under the grey pavements of city streets. It had been felt to be natural, and certainly economically correct, to site processing plants close to the source of the raw materials. Three pictures leapt readily into his mind: the Potteries in Staffordshire; steel in Corby; and the Fletton brickworks. It had also become accepted planning practice in urban conurbations to site manufacturing, processing and recovery plants - particularly those giving rise to excessive noise, fumes and bad odours - on the periphery of urban development so that the unpleasantness unacceptable to urban dwellers was directed towards the less rural areas.

The man in the street was often unaware that in solving his own problems he was merely adding to the problem of rural pollution and Mr. Free had no doubt that he would be astounded to hear himself accused of creating acid rain over Scandinavian countries. He asked whether these were not direct results of both planning and "high chimney" policies. To this had to be added lower land prices and councils eager to obtain contributions to the rates, and the setting up within rural areas of offensive trades and industries which had proliferated, giving rise to dust from quarries, cement, and other mineral works, acid gases from burning of PVC cables and many others, all adding to the total sum of rural atmospheric pollution. He wondered if Mr. Holmes saw any change in that situation. It was heartening to know that the NSCA was focusing its attention on such ever increasing problems. We each had our own particular problems, one of several in the Huntingdon district derived from emissions from brickyard chimneys - a matter under the jurisdiction of the Health and Safety Executive - although the complaints fell most heavily on District Councils.

He thought that attention should not be diverted from total emissions from brickyard chimneys which contained small amounts of hydrogen sulphide and other mercaptan compounds, giving rise to the particular smell associated with brickyards, but it was known that fluoride emissions had caused fluorosis in cattle, resulting in lameness and reducing lactation. It was stated that there is no definite evidence of danger or hazard to human health - but it was difficult for the public to accept that when the effect of SO_2 emissions on galvanized iron sheds and fencing could be seen so readily, or when dense localised fogs occurred in the vicinity of brickyards. He asked whether at some future date this matter could be the subject of a paper before a conference of the Society?

Mr. Holmes had referred to the desire of many town dwellers to change their dwelling environment from towns and cities which had lost their hearts and character by demolition and development to the peace, tranquillity and pure air of the countryside only to find that one irritation was exchanged for another - traffic, people, smells and urban noise were replaced by mineral working traffic, the smell of pig slurry and chicken waste and the noise of fans on intensive breeding houses - all aggravated by the rapidly increasing population of ex-town dwellers and smoke and smell from recently quitted towns. In future decades country dwellers might even be picnicking in the peaceful solitude and enjoying the clean air of the cities!

In the present days of financial stringency which many councils were either postponing or abandoning their programme he wanted to ask the Society - what price Clean Air?

Cllr. K.V. McElvenney (South Yorkshire M.C.C.) said that although the 1974 Control of Pollution Act had been welcomed, as far as it went, in giving Metropolitan County Councils the right to control and license the activities of private waste disposal companies, it had said nothing at all about the responsibilities of those engaged in research, who, by virtue of the very nature of that research, produced waste in solid or liquid form for which the technology did not exist to dispose effectively and safely of the waste products which came from their operations. He felt that one subject which seemed to be studiously avoided by commentators on environmental pollution, was the responsibility, the social responsibility, of scientists and chemists producing new materials and new techniques, which, in turn produced new wastes which were difficult, and in some cases, impossible to dispose of. It was the health implications of that that greatly concerned both his fellow members of the South Yorkshire Environment Committee and their excellent team of officers in the Waste Disposal Division of the County Environment Department.

Only recently they had discovered that a firm engaged in recycling waste oil had dumped the residual waste into a quarry, because there was no chemical method of treating the waste to render it harmless. Having filled the quarry they had then surface dressed the site. But the real problem had emerged when it was found that the surface dressing was heavier than the oil waste and was sinking. The oil and the sulphuric acid used in the recycling process came to the surface and children and animals had been getting on to the site. One could imagine the possible tragic consequences of that. Fortunately no serious accidents which had involved either children or animals had been uncovered. But the hazard was there and the County Council looked like having to find the money to put the situation right at considerable cost to the rate payer. Other examples could be given of toxic or dangerous waste which was just dumped; blue asbestos, radioactive and nuclear waste etc., for which the technology did not exist as yet to render them harmless, and all constituted a health hazard. No doubt there were many others which came under this particular heading.

He cited the tragic case of the tanker driver at Pitsea who had been engaged in the disposal of one liquid waste which, when poured on top of another, produced a chemical reaction, which had caused him to die in a matter of seconds. Thousands of tons of liquid were dumped annually and there was insufficient knowledge available to both the private waste disposal company or even to chemists which would indicate a reasonably cheap way of disposal but which would at the same time render it harmless and reduce the risk of possible death or of damage to people's health, whether they were people engaged in a particular industry or just members of the public.

But it was the activities of chemical researchers which really frightened him. Men and women were engaged in the production of new chemicals and new materials for industry, agriculture, and possible military use, not just in the U.K. but all over the world, and at the behest of their masters were producing not just waste but new herbicides and crop sprays, chemical defoliants, (widely used in Viet Nam without knowledge of the long term effects on the ecology of that country) and as a consequence of the activities of chemical engineers new plant, which despite assurances did not contain a fail safe device, resulted in a discharge to air of toxic gases of which the long term effects on either the atmosphere or to the flora or fauna of the country concerned, were also unknown, with the additional possibility of that pollution being carried on the wind to adjoining countries.

It was almost possible to charge industrialists with culpable negligence over the damage they were likely to do to the physical environment. He seriously suggested that before any new chemical was released by the private developer on to the market for agricultural use or whatever, there should be some compulsion,

by way of government legislation, to do research into the long term effects of those chemicals on the ground, or on water, or in the atmosphere. There should indeed be a government department devoted to monitoring chemical and biological research to whom evidence should be submitted by the researchers into the long term effects of their particular product, with proof that they had produced the necessary technology to deal with the resultant waste and that they could say with certainty that the release of that particular chemical or waste to either ground, water, or air would not have any further disastrous consequences. Such a government department could then, after checking those findings, issue a licence to manufacture and distribute those chemicals, providing that the technology existed to dispose of their waste and that there would be no possibility of any toxic reaction. He did not doubt that someone would say that his suggestion was impracticable. But the plain facts of the matter were that unless something was done very soon about the amount of chemicals that were shoved into the ground or the amount of alkalis and acids that were pushed into the atmosphere a chain reaction could be started in some cases which no one would know how to control and which could have dire consequences. He thought we were virtually sitting on a chemical time bomb waiting for some mad man to light the fuse.

He took the view, that if the conference was to achieve anything from its deliberations then its officers should go away with a firm objective in mind, and that was for a further strengthening of the 1974 Control of Pollution Act to include a government department concerned with the monitoring and control of present chemicals, and for new ones in the course of development. If the fullest support was not given to such a course of action then man would go on to develop new chemicals and new technologies, which initially might be to man's advantage, but in the ultimate might lead to his destruction. Time was not necessarily on our side. Indeed we might have gone too far already.

Dr. A. Parker (Vice President) said that he had read with interest the paper presented by Mr. Holmes, partly because he had spent many happy times tramping in the Peak National Park and partly because he had followed to some extent the methods of excavating limestone and making quicklime from it. As stated in the paper, both the Alkali Inspectorate for England and Wales and the High Peak Borough Council were involved in steps to minimize pollution from the various operations. The Alkali Inspectorate was involved under Item 37 in the list of scheduled works if the lime works included the burning of calcium carbonate or calcium magnesium carbonate through the agency of coal or oil. They were not concerned if gas was the fuel used for burning the limestone. If it was burned through the agency of coal or oil, the requirements of the Alkali Inspectorate began at the first crusher of the excavated limestone and continued to the production of quicklime. They did not include the excavation of limestone.

Dr. Parker quoted from the 111th Annual Report, for the Year 1974, of the Chief Alkali Inspector for England and Wales where it said "The reduction in the numbers of registered kilns (in 1974 compared with 1966) does not mean there has been a decline in lime burning. Several kilns have been converted to natural gas firing and some of the newer types of kilns have also been designed to use gas. This makes them non-registrable. Lime works were scheduled under the Alkali Act in 1958 because of their black smoke emissions, but as these have been reduced or become non-existent, it has become obvious that there are severe dust emissions which were previously screened by the smoke. There are many sources of dust from lime works and it was not at first realised that some emanated from the kiln gases. At the first opportunity we shall have to consider scheduling all lime works so that all can be properly controlled for dust emissions."

During recent years so-called rotary kilns and so-called rotating kilns had been introduced. In broad terms the rotating kilns were similar in operation to

cement kilns. They should avoid the production of smoke and there could be methods of greatly reducing the emission of dust from burning the limestone.

Professor C.J. Stairmand (Clean Air Council) remarked that there appeared to be some kind of fashion in the incidence of particular diseases: chronic bronchitis, tuberculosis and lung cancer had been the scourges of particular periods, and as indeed Professor Howe had noted, one of the modern phenomena was the rapid rise in acute neuroses with more and more people needing treatment for mental disorders. He asked to what extent Professor Howe believed those disorders were exacerbated or caused by the continuous propaganda from the media concerning particular 'incidents'. He referred to his local Press where banner headlines had referred to "Clouds of greenish-yellow gas from a nitric acid plant" - an erroneus and emotive inference that poisonous chlorine was involved.

He agreed that extreme care should be taken to understand processes and to disseminate accurate information through approved sources. He asked if Professor Howe agreed that uninformed, emotive utterances could be counter-productive.

Cllr. D.F. Haynes (Mansfield DC) said that several years previously he had visited a coal-mine in the Soviet Union. At the particular pit he had visited there had been a fairly thick seam - about 13-14 ft thick. He had been amazed to see that the men on the day-shift came out as clean as when they went in. The Manager of the Colliery had explained that this was because 8 hours were spent on infusing the coal face with water and, for this reason, there was no dust.

In his area, there was a problem of dust from stone quarries and he wondered if the water infusion method could possibly be tried to help this particular problem. What worried him were two particular stone quarries in his locality, one adjacent to a housing estate from which came regularly problems about the question of dust, so much so that when the shot firing took place, if there was very low cloud at that particular time, he had sometimes been nearly blown out of bed in his house three miles away, because the clouds had been so low and that the explosion had had to spread. On such occasions there were of course all sorts of complaints from people in the locality about the problem. But the other and more important thing worrying him was that a quarry fairly near to his house and fairly near to a hospital, and at the same time very near to a new housing estate, was expected to be developed in the not too distant future.

Mr. T. Henry Turner (Individual Member) commented that Mr. Ian Holmes' paper on Rural Pollution - The High Peak, Derbyshire, was professionally balanced and helpfully informative. With other members of the Society's East Midlands Division he had been permitted to visit the vast Tunstead quarry near Buxton during the 1976 June heatwave.

He had been especially grateful to Mr. Holmes for supplementing the rather rapid introduction to his paper with such a splendid collection of coloured slides that had provided a much wider knowledge of the Peak District's beauties, and the problems of industrial noise and dust.

As the audience had entered the room, Mr. R.V. Tomlinson C.E.H.O. had underlined the efficiency of his department of High Peak B.C. by giving each delegate a copy of their unusually attractive 63 page booklet 'The Peak District'. As the NSCA had grown it had naturally tackled urban grime. In the Midlands the outstanding success had been brought about by Sheffield's people, industry and local authority teaming together in making their City benefit from clean air. Now he felt that the most welcome part of Mr. Holmes's printed paper had been that which showed how people, industry and authority, in the mainly rural High Peak area of Derbyshire, discussed environmental problems, set objectives and disseminated unbiased information.

Mr. R.W. James (Lodge-Cottrell Ltd) pointed out that the technology was available to overcome virtually any dust pollution problem. This technology was available from British sources and only required the determination on the part of the offending companies to ensure that the emissions were acceptably reduced. Quite obviously most companies did not take action unless forced to by the Clean Air Inspectorate as there was usually no profit involved for the company concerned. For this reason he was convinced that the powers of the Clean Air Inspectorate and Alkali Inspectorate needed to be extended to cover more than just the scheduled industries.

On a number of industrial applications where emissions from sites occurred, it had often been found that the cause of the problem was bad housekeeping and plant maintenance rather than any failure or imperfection on the part of the gas cleaning equipment. It was not unusual for spillage from conveyors in gantries high above the ground to be swept off by labourers with the resulting dust cloud as the spillage hit the ground. That sort of thing was unacceptable and unnecessary.

Following the previous speaker's comments on dust emissions in quarries, Mr. James pointed out that much was already done in the Iron and Steel Industry where emissions from ore unloaders were suppressed by water sprays. Similar treatment could possibly be considered in the quarrying industry.

Mr. Holmes, replying to the discussion, said he would turn first to Mr. Hayne's point about how much was spent on Pollution Control. He said that High Peak received in excess of £$\frac{3}{4}$ m. in rates from the quarries. In 1976 there was a budget in a time of financial restraint of £7,000 for new equipment and about £16,000 to spend on the two smoke control areas. Salaries were not included in that figure, there was £16,000 in the smoke control area, £6,000 - £7,000 on equipment, and probably about one third of the staff were working full-time on pollution control, which in High Peak would be about 3 or 4 health inspectors. Mr. Hague had talked about the drop-ball technique. Mr. Holmes was pleased to explain that in High Peak most of the rocks were broken when they fell using a drop-ball technique. But popping did still occur. The men were reluctant to bring the drop-ball machine across to break large rocks and it was quicker just to take 5lb of explosives to it and blow it; it did occur and these infractions were discovered as the inspectors went around. Quarries in the High Peak area drilled 3ft below the quarry floor, and the reason for the drilling of holes 3ft below and packing it with explosives, was so that when the quarry face fell, a level quarry floor remained. At one time it had been customary to finish drilling just level with the surface, but it was found that where the face fell over it left rock probably about 6ft-12ft up, probably at an angle of about 45^{o}, and they had to fire stumping shots off, which were very similar to popping shots from the nuisance they caused.

He was glad to say that all the quarries were equipped with wheel washers. The only problem found with them was that if they were sited too near the quarry entrance, the trucks came off the wheel washers, they were still wet, and the road became caked in mud and limestone. So it was important to have the wheel washer sited quite far back from the road, as indeed most of them were. There had been mention of the houses on the heath where the principal complainants lived. He did not think that it had been a lack of foresight by the planning department; there was just no where else to build. All the valley bottoms had been built up, so it was necessary to build on the upper slopes. What he did consider a lack of foresight was to allow further industry to be established in the Valley bottoms, which would pollute the upper slopes. Everything was done to try and stop the sort of industry with a high pollution potential being attracted into the High Peak situation, because it was wrong for it to be there.

A question had been raised about the filling of quarries. There were only two

publications that he could think of, one in the Surveyor, in January 1976, which he thought had discussed the Blue Circle Group, and how they had filled a chalk quarry with two meters of clay, puddled it, and drained it; they had taken the effluent off and were going to treat it. They had reckoned it would satisfy the water authority. Some work done by the Greater London Council had been published in the Institute of Public Cleansing Magazine either 12 months or two years previously. It had again dealt with a clay pit, where there had been problems with the water authority because of the fear of polluting the aquifer, and they had also got away with it in the same way by puddling it with clay for a depth of something like 12ft-15ft, laying land-drains, then draining the effluent off and treating it. So it was possible to use the quarries for filling; it then became a question of what materials should be put in. He did not wish to see the quarries in his area used for tipping toxic waste as it was also a water catchment area. He thought great care would need to be exercised over the type of waste allowed to be tipped into the quarries.

Turning to Mr. Free's question, it had not been possible in High Peak to site industry on the perimeter as there really was no perimeter. The valleys were very much like box canyons - it was necessary to travel up the side of them to get out. Another problem was how the valleys were ventilated, and the health department had been trying to carry out some sort of micro climatic survey so that the way in which pollution travelled in the valleys could be determined. An interesting situation was occurring in that a volumetric machine had been established out at a place called Crowden, where there was nothing but sheep, and on some days readings were probably 3 to 4 times higher than the volumetric machine situated in the health department's office, right in the centre of industry. The volumetric machine at Crowden was right at the end of a boxed-in canyon, and the health department were concerned about how pollution travelled around the valley, and they wanted to know more. Therefore they were at present resisting dirty industry in High Peak. It was also an area of quite high unemployment and it was really a political decision whether to allow industry; the politicians had to balance employment against pollution. The establishment of dirty processes had been resisted quite easily, since the health department had become part of the planning function. Where it had been stated on environmental grounds, that development should not be allowed, the planning department had been very cooperative and had put up all the reasons on aesthetic grounds why it should not be established, and the health department had done the same sort of action for the planners. He gave a recent example where a firm of developers asked to build some housing on one of the upper slopes; from an Environmental point of view the health department had not been really bothered. But the planners had wished to resisit this development, because they thought it was ribbon development - joining two villages together. The health department had gone to the public enquiry and had put up all the environmental reasons why it should not be there. So good co-operation existed when a balance could be achieved, cooperative management in effect.

Mr. Free had talked about the changes in High Peak. Mr. Holmes said that High Peak had changed, since reorganisation. He had not known it before reorganisation, but going back through the records, he thought it was now a lot better than it had been. He could not call it perfect, but it was a lot better. There were now a lot of liaison committees established with different industries. The first one had been with a large American corporation, which had a large factory giving off a lot of chrome oxide and a lot of noise. It was right in the middle of what had now become a conservation area which was known as Old Glossop and the health department had persuaded the residents to appoint two spokesmen, and invited the company to attend the meeting. The chairman of planning, the chairman of health, the health inspector and the planners, had all sat around the table and discussed the problems the people had been complaining of. It was found that once the people began talking to the company, the council officers did not really have to do a lot of work because they were solving their own problems. The health department had provided them with before and after appraisals of what was going on. This had been done for free and it had cost a lot of time in man hours, but nevertheless it was a more positive

approach to pollution control, and one which kept both parties happy. It was then applied to a chemical company, and a similar liaison committee had been set up. Only two meetings of that had been held, and it was going well. One thing discovered was that these liaison committees had to have an objective or they did not work. Once the residents were satisfied then Mr. Holmes thought they ought to be disbanded. It was also necessary to dispel the feeling residents felt of having some executive power when they came to the liaison committee meetings, because it was very wrong for them to feel that they were taking over the job of the health department or council. The success of the first two committees had been encouraging and the third one had been held with an alloy manufacturer and the people from the heath, bitter complainants, who instead of sending two or three people to sit around the table and discuss it with the council and the company, had all turned up in force. They had brought with them a man who had lost his seat on the former council, and also the former chief inspector from the council. Then it had developed into a witch-hunt about how incompetent the health department were being, how competent they were being, and altogether great care had been necessary. Some people had been told some home truths; a little bit of straight talking did no harm in such situations. But the department were now going to extend the liaison committee meetings to another company, they had not been daunted by the third one that had gone a bit wrong. It was a question of keeping a tight grip and perhaps only having two or three meetings, attaining the objective, then disbanding them.

Mr. Holmes said there were quite a lot of brick works in High Peak, and that they were quite lucky, in that most of them had either Manchester transverse arch kilns or Hoffman kilns. They were coal fired from the top, and were on the side of a hill. They did smoke not infrequently, but were not too bad really, not so bad as some of the transverse arch kilns he had dealt with in the past. The brick works had made an application to extend the shale quarry. The planners had insisted that they should build a new brick works. The health department had said the existing brick works would have caused a lot of pollution if they had started to try and force brick production. They had got them to agree to build two new gas fired Car Tunnel Kilns which, of course, were the answer to the smoke and fume problem and everything else. The problem of odour, referred to by a speaker, had never been experienced, probably because it was shale. But when he had worked in Manchester where the brick yards had been of the Manchester transverse arch type, they had been burning clay and there had never been an odour problem there, and the only reason he could assume for this was that the critical temperature stage of around 350°C had been passed quite quickly. Also the transverse arch kilns had quite large wickets and so when they were burning it was possible to get a retention time of 0.5 of a second at 850°C, which consumed odours.

Dr. Parker had mentioned that the Alkali Inspector wanted to take over more work in the quarries. Mr. Holmes did not wish to see the Alkali Inspector expand further his functions in the quarries. He thought Health Inspectors had the expertise to control processes that were basically combustion processes and mechanical processes for dust arrestment. They had equally as much expertise as the Alkali Inspector in this field, and would not wish to see his duties extended. He was not proposing that Health Inspectors should take over the Alkali Inspector's function with regard to lime kilns, chemical plants and things like that and his local authority had submitted evidence to this effect to the Royal Commission when it was at High Peak; it had been stated that no reason could be seen why the Health Inspector should not control combustion processes and mechanical dust arrestment processes. The local authority were politically and socially accountable to the people in the area, and since the Alkali Inspector was based in Manchester, this was where he lost out. It had often taken something like 48 hours to contact him. It was not his fault if he was already out, but he came on the scene when the scent had gone cold. So Mr. Holmes preferred that the Health Inspector should retain his functions in the quarries.

Turning to Councillor Haynes' point about infusing the quarry face with water, he

said that it might be possible to infuse a mine with a seam of 14ft with water, but not to infuse a face that was probably something between a 1,000 and 2,000 yards long, of limestone that was 120 ft high. There just would not be that amount of water available. There was also the fact that if the face was infused, the water had got to drain somewhere, and one of the problems in quarries was flooding. Mr. Haynes had also spoken about living 3 miles from a quarry and being blown out of bed when they blasted. It was not uncommon for Mr. Holmes' department to get complaints over a considerable area; the height of the inversion was now ascertained from the Met. Office and the quarries had agreed not to blast on days of low cloud or when there was an inversion below 1000 ft.

Referring to Mr. Turner's point about visiting Tunstead, he said that he had not mentioned in his paper that Tunstead Quarry was believed to have the largest face in Western Europe. It was over a mile long - with an average height of around 100 ft.

On Mr. James' point about technology, he fully agreed with him that the technology was available for dust and fume arrestment. The problem was the performance of the companies. If Hawkins' and Smith's quasi-mathematical formula, that performance is equal to motivation times ability, were assumed, he thought the performance of quarry companies in his area in the past 12-18 months - 2 years would be found to be superb. That was because the motivation had been there, since the limestone reserves that they had planning permission for were running out, and they needed to have planning permission for a much wider area in the Peak District National Park to take them on for another 75-100 years. Consequently they had put their own house in order, to make themselves appear all clean and white to the public in the hope that they would not get as many objections to the planning permission when it came up. In the event, the Public Inquiry had already lasted many months, and the result was still not known.

Professor G.M. Howe, in reply, stressed that he was a geographer, not a professional Health Inspector or Alkali Inspector and that he could not speak about the nitty-gritty of the various papers. He took encouragement from John Snow, from the fact that his improvements in sanitation had preceded the findings of Koch and Pasteur and the introduction of the germ theory. Snow had drawn the cholera map of Soho, showing the incidence of cholera around a polluted water pump in that area. He arranged for the removal of the pump handle and the cholera had subsided. It was he who had discovered the mode of transmission of cholera some 40 years before Koch discovered the cholera vibrio. Professor Howe thought that much the same kind of thing applied to the work that the Society were doing. Who knew but that that the endeavours to reduce the intensity of pollution of the environment, particularly atmospheric pollution, might well bring about an improvement in man's health independent of the medical profession.

He had earlier commented on the fact that the acid rain in Scandinavia was the U.K.'s greatest export, although he did not think we should take all the blame. One should bear in mind that our climate was one of cyclonic control. Depressions or low pressure systems passed over us regularly and he considered that the talk of 'prevailing wind' from the southwest was nonsense. There was no such thing as a prevailing wind in Britain. There might be a net movement of air from West to East, but the wind could blow from any direction. In that context one should not forget the Ruhr industrial region and other industrial regions in Europe which might well have their pollution blown up over Scandinavia to give acid rain there.

He recalled the remark made by Mr. Hague who referred to the containment of pollution. We had the necessary technology to do this. Given the financial backing and the will, we could most certainly get rid of most of our atmospheric pollution. It was really a question of industrial competitiveness - whether our industries were placed at a commercial disadvantage, costwise, for having to contain pollution.

Referring to the remarks on high-rise flats, he said that Glasgow, where land was at a premium, had been one of the first local authorities in this field. Some of high-rise blocks had twenty or more storeys. It had since been discovered in Glasgow that such high-rise buildings were particularly anti-social and so the authorities were going back to the tenement blocks six to eight storeys high. Seemingly from the social and noise viewpoints high-rise blocks were taboo.

The question of noise was of interest. People of a nervous disposition living near airport runways became very agitated about the noise of jet aircraft. The noise produced insomnia and psychoneurotic manifestations. On the other hand, to the teenager, the roar of a jet aircraft taking off could excite the imagination of the youthful adventurer. It was a question of temperament. It was much the same with community pollution and/or personal pollution - i.e. cigarette smoking. One could be a cigarette smoker all one's life or spend one's days in a polluted environment; some people succumbed, others reached a ripe old age of 90. It was all a question of response and this was conditioned by the genetic make up of the individual. In the context of the Conference, the concern was with our external environment but one should not lose sight of the internal environment. Heredity, or constitution, was most important. It meant that some people suffered adverse effects from environmental hazards while others reached the Biblical three socre years and ten. Professor Howe then commented on the question mentioned by the Chairman, that of euthenasia and the conflict with the Hypocratic oath. There was no doubt but that in Britain the age structure of our population was top-heavy, i.e. many old age people relying on pensions and social security supported by a relatively small working population. It was indeed a big worry whether aged people who had lost the use of most faculties should be kept alive, or indeed wished to be kept alive. It was an ethical matter which he preferred not to discuss. In India, South East Asia and China, where there was a population explosion, the people were anxious to industrialise; they gave little thought to the accompanying environmental pollution. They thought that 'where there's muck there's brass'. Quite frankly they were not interested in environmental pollution so long as they gained an improvement in their abysmally low standards of living, some financial wherewithall with which to improve their nutrition. It was an enigma whichever way one looked at it. On the one hand, DDT was being used to kill mosquitos, the carriers of malaria. The curtailing of malaria contributed to a population explosion which, without necessary or adequate food, suffered from malnutrition. To obtain necessary finance they imported industries which gave forth pollution, and some of the excess population may be killed off that way.

As a geographer, he considered that the Society and delegates should endeavour to maintain a sense of balance and not be myopic. One should not blame atmospheric pollution or environmental pollution for all our ills. Taking bronchitis as an example, he said that many people thought chronic bronchitis was due to or caused by atmospheric pollution. He wondered if this was really the case. There were not many cases of chronic bronchitis in persons of socio-economic classes 1 or 2, instead they came mostly from socio-economic group 3 or 4 and below. One had to balance these things and look at them against a broad canvas instead of assuming polluted air to be the culprit. He was encouraged by the remarks made by Cllr. Haynes as he had, more or less, reiterated what he himself had said in the last paragraph of his paper. Professor Howe closed by repeating that final paragraph:

The environment was under constant interference by man. Some of the changes being wrought were imperceptible and insidious, others blatantly obvious. What was beyond doubt was that man was altering the balance of a relatively stable system - the ecosystem - by his actions. The ecology of life in Britain and on planet Earth was being radically changed by man's actions. We were interfering with God's earth. From the health point of view, some of the changes may be good, and one liked to think that the kind of things the professionals present were doing were all to the good. Some may be harmful, and in that context we tended to blame some of our industrialists. Other changes being wrought might prove to be catastrophic, e.g. genetic changes being brought about by radioactive radiation. What was

important was that there were, at present, no precise views of the impact or effects of those changes on the balance of the natural forces and of the new environment being created by man. This was cause for serious concern. He suggested that it was palpably unwise to continue to interfere with the natural environment without at the same time striving to determine the real and lasting effects of our actions on human health and general well-being. The nuclear energy programme was a case in point. To ignore potential effects was to court disaster, indeed, it could lead to the death of tomorrow.

OPEN SESSION

SOLAR ENERGY

Dr. J.C. McVeigh
P. Brunt
B. McNelis

Professor R.S. Scorer (Clean Air Council) thought the presentations had given the impression that when the fuel ran out we were all going to be saved by technology! He asked the audience not to believe it. He argued that the alternative sources of energy were presented as a sort of shop window in which we had only to make our choice, but that none of the alternatives were anything like as good as oil or coal. They could not possibly do the job expected of them. He said that energy demand had been discussed as if it were something that was going to be satisfied, but that, on the contrary, we were going to have to learn to live by the expenditure of much less energy, and the greatest contribution to resolving our predicament was to learn as quickly as possible how to do that.

In spite of our technology, he considered we were the most inefficient generation that had ever lived. We used far more energy to get though life than had any of our predecessors. In making a test of the economic viability of the alternatives we used the criteria of today's accountants who were backing up the most spendthrift era in all history. We were living on capital. The criteria amounted to saying that it was more economical to spend capital that happened to be in the bank than to go out and earn a living: we could not accpet that, nor could we accept that anyone had proved that solar energy was not viable. He said that the criteria of economic viability put before the conference was utterly mischievous, and wished to offer instead a motto of the Maoris of New Zealand - "We do not inherit the earth from our forbears; we borrow it from our successors". He added that everything that was borrowed was spent, it could not be handed on: that was plain thieving. We were thieving the world's resources from posterity and expending them on frivolity.

He thought that many of the pieces of technology shown had been described as if the objective were to feed all energy available into the grid. What was needed was double glazing and solar panels on our houses: triple glazing if possible, together with a less complicated technology.

He considered coal to be better than wood as an energy source, and oil better than coal. Nothing in prospect was better than oil. He felt that nuclear energy was extremely expensive and had many social dangers. These facts should, he argued, be the basis of discussion, and it was wrong to talk as if there were alternatives to keep our present extravagance going.

Dr. J.C. McVeigh said in reply that he had been delighted to hear many of Professor Scorer's comments, particularly those about accountants and living on capital, and would agree entirely that we must learn to use less energy. He had thought that this had been part of his message, but he obviously had not made that quite clear. He thought that in his comments on the June Energy Conference, he should have added that Dr. Walter Marshall's group had put forward several energy scenarios. Every single one of them had showed a growing energy demand. They had completely ignored the possibility of the scenarios in which our energy demand would eventually start to decrease. This was a forecasting technique which had been used in the Netherlands, and the Netherlands' scenario was looking at a present 4% growth in energy consumption reducing to zero by the year 2000.

He also agreed with Professor Scorer's comments about using solar energy in

housing, and said that higher standards of insulation had to be accepted, particularly in council housing. The first thing one could do to save energy would be to put four or even six inches of insulation in the loft. A survey had been carried out at Brighton Polytechnic of people who were interested in installing solar water heating systems. Half way down the questionnaire had been asked the question 'Have you insulated your loft?'. About half the people who had been prepared to spend hundreds of pounds on a solar water heating system, which at best, could perhaps save 1500 or 2000 kW hours annually, had not insulated their lofts. They had therefore been throwing away £50 per annum, and it could be seen that a tremendous job remained to be done in educating people to think about energy.

Mr. P. Brunt although glad to hear Professor Scorer agree with Dr. McVeigh, was under the impression that perhaps he did not agree with him. When talking of delving into capital rather than saving, the example Mr. Brunt gave was that £1,000 of capital would be better spent on a solar energy installation than burning fuel that was being borrowed from future generations. The utilisation of solar energy initiated now, would help save for future generations the fuel they would need for other and more important purposes. He thought that the sorts of energy sources that would be used in the future were nuclear fusion and probably much more advanced forms of geothermal energy and solar energy than were currently being discussed. He recognised that insulation was needed, but thought it was a separate point because once a house had been insulated, some form of energy was still needed to heat it, etc.

Coming from a mining family himself, he was not sure that miners would agree that coal was easy to use. It was easy to burn, but it was not easy to dig out of the ground. The point he felt most sensitive on, was that an advanced Watern Society was saying that, in future, economics should be run in a different way. He thought that no-one in the developing world would listen to that kind of argument. One was trying to tell them that they should not try to build up their industries, to process their own natural resources, to get their hands on some of the wealth that the west has enjoyed. He did not believe there is any way they could be convinced of that approach.

Cllr. J.B. Crann (Gateshead M.B.C.) explained that he spoke as a layman, being in no way a practically qualified person, but an elected member. Government ministers, Lord Robens, Richard Marsh and many others had stated that there were vast resources of coal underground, which might last for between 150 and 200 years. Prophets of doom had variously estimated the date at which North Sea Oil would run out at between 15 and 40 years. It had also been predicted that North Sea Gas would not last much beyond the end of the century. He was absolutely bemused by the variations in the pronouncements of such scholarly and learned people. It could be guaranteed that when one person said one thing, one or two years later some other learned person in an equally high position would say exactly the opposite. He asked whether it had really been beyond the intelligence of a well-educated nation with an advanced engineering technology, in an island surrounded by water, to cope with the drought experienced in 1976. He pointed out that similarly, a perpetual action of nature, the tides of the sea going in and out four times a day, was not being harnessed. Here was an absolutely fundamental, everlasting source of energy which no-one had had the courage, the intelligence or the pure and simple common sense to harness to the fruitful use of the whole nation.

Having sat in the conference room all week, he had been very annoyed at times with some of the comments from people more learned than himself. There had been a doctor who had scathed the miners for giving away, or selling, their concessionary coal. He thought it was very cheap to come to the rostrum and waste the

conference's time on such a churlish condemnation, the truth or otherwise of which could not be proved. He would have expected people of such calibre to put their efforts to better use. The great bonanza of nuclear energy was now being proclaimed as the monstrosity which would exterminate the whole human race were it not to be kept thoroughly under harness and surveillance. The country had also been told that North Sea Oil would not last very long. He remembered that when Richard Marsh had been Minister of Fuel and Power, the mining areas of Durham, Caernarvon and Carmarthen had been denuded and many good miners, the most independent workers in the world, put out of work, all because of the great white hope for the future of unlimited North Sea Oil for nothing. But the prophets of doom were now saying it would be far from free. Addressing the younger members of the audience, since it was their future at stake, he asked why the economic viability of harnessing tidal power at the various inlets and bays around the UK was not being investigated, since it would provide the cheapest source of energy for ever more. Speaking as a Chairman of Consumer Protection, he reminded the audience that everyone was a consumer, and that the one thing most important to all was whether the particular commodity or service would supply what was required. The second thing to be considered was whether it was economically viable and could be afforded.

Mr. H. Brown (Chairman of the Session) agreed completely with Mr. Crann's comments on the question of economics and of sinking money into these projects. He hoped that in future when decisions had to be made, people like him would willingly put their hands up when asked for the money to put these schemes into effect, enabling us to preserve our energy for future generations.

Mr. P. Brunt reiterated that one of the big problems of the introduction of Solar Energy was predicting the future. Cllr. Crann had put his finger right on the problem. Mr. Brunt believed that everybody had a view on whether things were economically sound and what the basis of calculations were. And every miner had a view on whether he should stay in work, and every electrical power worker felt that electricity was the future, and so on. He thought that what people were trying to do was to find the cheapest source of energy for ever more. But it was not necessarily tidal power, people did not always agree on that. It was not necessarily solar energy. His point was that these were marvellous stop-gap measures to cut down the incredible rate of consumption of resources. He did not know if North Sea Oil or any other would run out in 2000 or 2010 or 2020, but it would not be in 3000, or in 2050. The actual year did not matter very much - it was going to run out, and at the present rate it would run out before nuclear fusion was developed. If it did run out, the only source of so-called easy fuel would be coal. Then the wonderful pronouncements of "We have 100 or 200 or a 1000 years' worth of coal at present consumption", would be shown to be nonsense, because present consumption would not be the consumption next year, it would not be the consumption in ten years' time and it certainly would not be the consumption when North Sea Oil ran out.

Miss Mary George (Clean Air Council) said she wished to sound a note of caution and expressed concern lest at present the domestic applications of solar energy might be exaggerated and oversold.

Several reputable firms were already in the field offering solar energy installations for water heating, particularly for swimming pools. It would probably be some time yet before solar energy would be feasible for space heating. But the subject was one which was already capturing the public imagination particularly in the context of energy conservation and anti-pollution, and there was the risk that the public could be taken for a ride by cowboy operators offering expensive and completely unreliable installations just as had happened in another area of

energy conservation with cavity wall filling and double glazing. Miss George suggested that even at this early stage there was an urgent need for the drawing up of standards for the design and thermal performance of equipment and Codes of Practice for the installation which would be accepted by all the responsible parties concerned. The British Standards Institution were already instigating some action in this direction of which Dr. McVeigh was aware, and it would be helpful if some endorsement of the need for standards could come from the panel and from the meeting.

The existence of standards and codes of practice would also help to counter some of the moreover optimistic and sensational reports by the media.

Mr. H. Brown said that he and the panel agreed wholeheartedly on the question of the cowboy operators à la double glazing, which was allowed to go on far too long before official people made mention of the restrictions that should have been looked at. He warned the audience to ignore claims that a certain solar energy system would save x% of one's water heating, because everyone's percentage varied and each case had to be calculated out on its own for family demand, water demand and so on. As for free heat from solar energy, he also pointed out that coal, oil, gas and wood were all free. All one had to do was find it, win it, transport it and use it efficiently.

Dr. J.C. McVeigh could confirm that the British Standards Institution were establishing a technical committee to look at standards of solar water heaters, which would include the materials with which they were made, the thermal performance and also a code of practice on installation. At present there were no solar water heater standards and he strongly advised people to seek professional advice, for example from a chartered engineer or a member of the Institution of Heating and Ventilation Engineers, who could advise on any particular quotation. The figure of 350 kW hours (or 350 units) per sq. metre of installation per annum was reasonable. There had been manufacturers who had been selling a unit with 800 kW hours claimed per square metre per annum which was quite impossible in this country for domestic water heating.

Mr. B. McNelis added a point about the comparison of different collectors. The European Community had started work through the Joint Research Centre at Ispra (Italy) on comparing different panels and finding suitable methods for comparison. They were also looking at identical panels in different climates. Panels were being tested throughout Europe and the Building Research Establishment and University College Cardiff were taking part.

Mr. H. Brown also recommended that advice should be sought from an engineer on whether the solar panel offered was likely to last the length of time it would take to recoup its money. A panel that was quite suitable abroad was probably quite unsuitable for the varying climate in the UK.

Mr. P.T. Jackson (Yorkshire & Humberside Pollution Advisory Council) said he would like to look at our present heating system as equilibrium - buildings were heated by burning fossil fuels and the heat escaped through the walls to restore the equilibrium. The domestic refrigerator took heat from the cold side and liberated it to the hot side. He asked for the speakers' views on the feasibility of this system, possibly using pumps driven by solar power to heat buildings.

Mr. B. McNelis replied that the heat pump for heating buildings was very well

known and extensively used in the United States and some experimental work was being carried out into such systems in the UK. The advantages of a heat pump commercially were that it could be used for cooling as well as heating, hence its use in the US. The capital cost of a heat pump in the UK was very high. Research work included using a conventional type heat pump, but with a solar collector, so that instead of taking heat just from the atmosphere, it was also taken from a source already heated by the sun. The Building Research Establishment were currently building a house using that system. Other work in progress included the use of a solar collector to drive an engine such as a freon turbine connected to the compressor of the heat pump (refrigerator) system. Mr. McNelis believed that many more buildings with heat pumps combined with solar heating would be seen in the future.

Mr. P. Draper (Chairman of Council, NSCA) said that his impression of all the devices referred to was that they were all very small scale and would not make any considerable impact in crowded, industrial countries such as England. They could, on the other hand, bestow great benefits in sparsely populated areas where electric power distribution was uneconomic. He acknowledged that he might be proved wrong; for instance if, before the days of exploitation of coal, someone had dug a hole and found coal, Mr. Draper might have thought it impossible to extract enough to power an enormous industrial country such as Great Britain. He thought attention should be payed to the remarks of Professor Scorer in his opening discussion, although he did not agree with them all.

Mr. Draper suggested to the young people present that it was worth making a small solar heater. He himself had a small one made mostly of corrugated iron and glass which provided up to 25,000 BTU's an hour or the equivalent of a small domestic boiler, which heated a swimming pool very well and was good fun. However, he could not see such devices replacing oil-fired power stations to any extent.

Mention had been made to power generation from the sea waves by means of floats called 'nodding ducks', and he asked the Authors to explain how power was collected from such devices.

Reference had been made to increasing food supplies by growing more on the land or sea and he considered this is a well worthwhile use of solar energy. Spinach had been mentioned as a good crop, and look what it did to Popeye the Sailorman!

Keeping houses warm by means of large windows had been stressed, but this should be done with intelligent forethought. It had been applied to schools in a big way in England and had been found that too much light and heat had often been experienced to the discomfort and reduction in efficiency of the pupils. Nevertheless there were thousands of cases where such easily attained benefits might reduce fuel bills very considerably.

Comments had been made on when North Sea Oil would run out but one did not really know to within 50/100 years or more. Mr. Draper was appalled by the tragic mistake of selling abroad this precious commodity to pay off ill-conceived debts. Future generations would curse us for squandering these power resources.

Mr. P. Brunt agreed that solar energy was open to the accusation of being small scale, just as he supposed, when gas had been discovered and one or two people lit their homes with it, it had been small scale. Thousands of years ago coal used in small fires had been small scale, and so on. But it took some time to get up to a society which could build big power stations to burn oil and coal. He believed that solar energy was in a similar position, at the beginning of its utilisation as an energy source. One of the attractions of solar energy was that

people would not be so dependant on centralised power stations, and he would have thought that decentralisation was an argument that would touch a chord in Scotland.

Referring to the point about window size, Mr. Brunt said there had been applications based on this. He knew of one school in Merseyside, Wallasey, but was not sure if it had been a total success. One of the problems of letting heat in through windows was that in winter the heat escaped through them. If one put in double glazing so as to keep the heat in in winter, the heat could not get out in summer. He believed that the movement now was towards smaller windows.

Dr. J.C. McVeigh said that Mr. Draper had made a number of interesting points, firstly about the power from the waves. He explained briefly that as the pointed end of the duck rose up, it could lift a weight due to the buoyant action of the water in the wave passing underneath that shape. The wave had very little energy after passing the duck. It was very straightforward to transform the lifting motion into work by conventional means.

On Mr. Draper's second point, he acknowledged that although all the speakers had been emphasising that North Sea Oil and Gas were running out, they still did not seem to have got the message across. Everybody in the industry who wrote papers on the subject seemed to think, as far as they could tell, that it would be round about 1990 when there would be a real decline in the production from those fields, and thereafter it was only a matter of a few years, perhaps 15 or 20, but not much more than that. There would not be oil and gas from the North Sea in 50 years time as there would be no more reserves left.

Thirdly, he agreed entirely with Mr. Draper about the incredible statement that the UK was selling North Sea Oil and Gas to pay off the nation's debts. This might have to be done in some way, as there had already been a committment, but it was being said that the British had reached such a standard of social importance in the world that it would not be right to alter the national way of life, or have the British turn their backs to the wall, put their spades in the ground and work their way out of it. He had heard somebody on the radio saying "Well, the Germans did it after the war, but we wouldn't expect the British to have to do anything like that", and he asked why not. What made the British so special in the world? Two thirds of the people in the world had a standard of living that was a tiny fraction of what was enjoyed by the great majority of people in the UK.

Making one final point on 'small scale' he said that this was not the case with the wind equipment which could be developed now. A small scale would perhaps mean a 15 foot diameter windmill placed in a garden for power in the home. The 150 foot diameter windmills, which would be suitable for providing power to the national grid, had already been designed down to the last bolt. A point which perhaps needed to be emphasised was that there was very little new in this technology and 80% of a modern windmill could be built from equipment bought off the shelf. In a final point on economics, he remarked that if in ten years' time it could be possible to supply 90% of our energy by wind, but that this would cost just a little bit more than the present nuclear programme, surely the country would rather do that, than see the nuclear programme going ahead.

Mr. P. Brunt said he had not really finished his point about small scale. One of the ways in which solar energy could be used to give a larger output was in thermal generation used in power stations. An organisation in the UK called the Commonwealth Development Corporation which operated electricity generating plants in many developing countries would confirm that electricity was enormously expensive in those parts of the world, much more so than in the UK. Often those countries have sunnier climates, and thermal generating plants that perhaps

did not sound too attractive to us might be just the thing. Here one was talking of megawatts of power, which was not small scale. He added that a large number of small scale installations were used in towns for example. If towns were designed with solar energy in mind, so that orientation of the houses and the shape of the houses were more amenable to using solar energy collectors, then these were quite large scale uses as well.

Mr. E.R. Hindle (South of Scotland Electricity Board) reminded the audience that they had heard it said already that he was from the Electricity Board. He stressed that he had come as a part of the audience to listen to what was being said, and was in no sense speaking for anyone other than himself: he was not a Board official spokesman in any way. However, he said that the Electricity Board had encouraged all its engineers who work in the utilisation fields to be energy conscious and, in fact, they encouraged industrialists and commercial people to use less energy where this could be justified. But they were tied to the economic system which had been getting some criticism, and his own outlook, as a commercial utilisation engineer, was commercial, and he made no apologies for saying that. On the question of the SSEB representations to the energy conference Dr. McVeigh referred to, he thought it might seem from the SSEB's outside representations that solar power had been dismissed, but within the Board it had had a very considerable discussion, a discussion in which he himself had been involved in a very small way. He remarked that some of the audience had seen the installations at the Napier Tech. The SSEB had had a debate over those a couple of months ago in which in fact, he had led the opposition, not because he thought solar power was not a thing with a future, but because he thought it was a thing without a present. Giving the example of the energy falling on Cornwall, at 5.6-5.8 watts per square metre in summer, he said that this represented the best bet in the British Isles and that in winter it was down to .6, and at .6 it was certainly not viable. Those, he said, were not his figures, but were from The Royal Institution and could be verified. He found worrying the kind of approach which took things in isolation and talked about averages.

He did not think that we could get away from financial considerations, whatever we said. We were, as Professor Scorer had said, delving into capital. In building a solar collector out of copper, smelting that copper with energy, the pollution created by that process and the energy consumed by that process went somewhere else inthe world, not in Britain, but nevertheless the processes were polluting, and energy consuming. When insulating our houses, either ureaformaldehyde or rock wool were used. Rock wool was made in Scotland; he himself had seen the plant. They melted the stone to a point where one could not look into the furnace without looking in through dark glass; this process used vast amounts of energy. The material was sprayed through nozzles and whilst in the air it was sprayed with plastic to stop it coagulating so it formed a wool. That plastic was oil based. Giving further examples; Mr. Hindle said that we double glazed our houses; we used aluminium which polluted Australia and Canada on a vast scale to extract, and on an even vaster scale to refine. We used glass in between it; glass was another substance which used vast quantities of energy in its preparation. Were we, he wondered, minimising our inroads into capital by doing these things? All he could say was that the energy balance was very difficult to draw. It was by no means as simple as it appeared in the first place and if one listened to Dr. Chapman of the Open University we were way, way on the wrong side of the energy balance in doing these things.

Turning to tidal power, Mr. Hindle said that he had been involved, again in a peripheral way, in the Morecambe Bay barrage scheme which was perhaps, one of the better schemes; it had a better chance of success. Saying that it had been dropped, he explained that the back-up of the water would have wrecked the ecology, the wild life ecology, of the entire Southern Lake District. The argument was to forget water, forget our greed for energy! Because the wild

life and the southern half of the Lake District would be wrecked, the scheme was not on. He had not looked at the Bristol scheme because he had not had the opportunity, but he suspected that this fell into the same category. He pleaded that it was not the best financial balance or the best energy balance that should be considered, but what was the overall balance for the world, when talking in terms of delving into capital. He thought we might well have to accept not a little less but a great deal less. Speaking as a power engineer, he emphasised that power stations were dictated by what the public required. If power stations were not big enough, the system would collapse when great demands were made on it. The public set the scale, not the wicked Electricity Board, and he did not think that this point could be over-emphasised. He stressed that the SSEB had looked into wind generation - at the current state of the art - for the energy conference. He pointed out that all that he said related to the present. It had been worked out that to supply 10% of our needs we would need a line of windmills with the blades just skimming each other at optimum size 350 miles long; Mr. Hindle thought that if that was not visual pollution, he did not know what was. He considered that these options were open to us but they were by no means as easy as they sounded. Mentioning orbital power stations beaming power down onto the earth, he said that the calculations at present were that with the present state of rocket technology the rockets would consume as much prime energy as the station would produce in its working lifetime. Or again, we could get rid of nuclear waste by blowing it into space; that would take as much energy as the power station would produce in its working lifetime. These things were not capable of simple solution and he was very disturbed to hear them presented as if they were capable of simple solution.

He therefore asked the speakers whether they really looked, as Professor Chapman did for instance, on a world wide scale at pollution, energy consumption, and the whole thing, when they made proposals in respect of what should be done here in Britain?

In a written contribution Mr. Hindle pointed out that since solar heat arrives as low-grade heat for most of the year, it had limited utility. Utility was greatly increased by up-grading, and an experiment in which the Board was co-operating was in progress in Livingston New Town, in which a heat pump extracted heat from under a black-tiled roof and passed it into the house. This appeared to be one of the more promising uses of solar heat, since it could still be used in winter, because the lowered roof temperature increased heat collection from the atmosphere.

Mr. H. Brown referring to energy balance, said he believed that it took about eleven years for a power station to generate the energy that went into building that power station in the first place. And on the question of, again, energy balance he considered that we had to decide, "do we want energy or don't we? Are we going to have hot dinners, or cold teas?" He suggested that Dr. McVeigh should answer that as he mentioned SSEB earlier in his speech.

Dr. J.C. McVeigh wished to say how much he appreciated Mr. Hindle's comments and that he understood his position. A crucial issue in the recognition of such problems was the question of pollution. There was one form of pollution against which there was no defence with fossil or nuclear power stations and that was thermal pollution, not just local but world-wide. In this respect only the sun, wind, waves and the tides were clean. All other sources - fossil fuels, geothermal, nuclear fission and nuclear fusion - were thermally dirty. Also fossil fuel burning had the additional hazard of carbon dioxide, and nuclear fission and fusion had the added radiation hazards.

On the subject of windmills, he thought the figures had been rather exaggerated. With 150 foot diameter blades, it was possible to get about thirty windmills per

mile if they were in a long line, which would not be necessary as they could be grouped in clusters. He did not think that Electricity Board could regard themselves as not being visually non-polluting, when the lines of electricity pylons across the countryside were to be seen. He was himself collecting photographs of pylons adjacent to houses, and there were many examples of people living with these large electricity pylons above them. Giant windmills would never be sited in the middle of housing schemes. They would be on exposed north-westerly sites, away from towns and houses.

He thought that Mr. Hindle's comments about solar energy being "a thing without a present" were not justified. He gave the example of a large application, such as a well-installed commercially available swimming pool heating system, which had a pay-back period defined as the capital cost divided by the annual amount of fuel saved, somewhat less than five years at current costs. This could be bettered with the simple system that Mr. Draper had described, where corrugated iron was painted black and water flowed over it, a do-it-yourself scheme. That would pay for itself in about a year or a year and a half.

Finally, he was sorry to have to refer back to the crofter's cottage but this was a superb non-polluting type of house. It had stone walls, a thatched roof and if a piece of glass were placed on its south-facing wall the odds were that the glass might last a hundred years or more. If the stones behind the glass were painted black, there would be a very good passive solar heating system whenever the sun shone.

Mr. P. Brunt said Mr. Hindle had made the very valid point that alternative energy was not as easy as it sounded. One could not but agree. He and his fellow authors were trying to draw attention, to some of the worrying aspects of the energy question. They had talked about fossil fuels running out - so neither were fossil fuels and power stations as easy as they sounded. They were, one could say, trying to put the other side of the coin. Mr. Hindle had made a point about the global situation and Mr. Brunt thought that was where they were trying to make a constructive point. The developed countries had consistently taken fuel resources as if they belonged only to the developed countries, and now they wanted to try and build up their industries, to stop exporting natural raw materials and actually to process them, and to try to get hold of some of the wealth referred to. The West could use its technology to try and give back some of the things it had taken; the alternative energy forms would be very helpful to developing countries. The energy picture - for example, how much energy it took to make a collector - was a figure he had at his fingertips which, he had always understood, was relatively low; even solar cells paid back the energy invested in them fairly quickly. But there was no way round that, he suspected, apart from going back to an aggrarian community and he did not think that that was what people wanted. We had to continue developing in some way, not as rapidly as we had been doing, but we had to continue developing on a global scale and alternative energy sources were a way of drawing attention to the problems that the world did not have enough energy to continue doing it in the way it had

Professor C.J. Stairmand (Clean Air Council) referred to the remark made by Professor Scorer and others, that we had to reduce our energy usage if we were to survive.

This was, of course, true, but we would not do this by tinkering with the problems, for example by insulating our houses and by fitting double glazing - useful as these methods were. Dr. Parker, in the excellent summaries of fuel usage in the UK (published annually in The Society's Year Book), showed that in 1973 domestic fuel usage had been less than 20% of the total, and the palliatives achieved by insulation and solar energy devices were unlikely to save more than a few

percent of this. The really worth-while savings could come with a complete change in the way energy was used in industry.

He said that the chemists among the delegates would know that a chemical reaction speeded up by a factor of two for each 10°C rise in temperature, and advantage was taken of this by running the processes at elevated temperatures. But instead of heating up only the reacting molecules, or even only the reacting surfaces, not only the whole of the reacting solids were heated up, but also all the carrying fluids. This lead to at least a 10,000 : 1 inefficiency!

He did not know how one could heat up only the reacting surfaces in practicable plant based on present day technology. This was where intensive research should be directed.

All the conventional chemical, metallurgical and combustion processes were prodigally inefficient in their use of energy as at present practised, and Dr. Stairmand thought that the encouragement should be to increase the efficiency of energy utilisation, rather than to exhort people merely to use less total energy while continuing to waste such a high proportion as at present.

Dr. J.C. McVeigh replied that if a user of large scale industrial process heat required considerable quantities of hot water, such as a laundry in the south of England, it made economic sense to install a solar water heating system, because large amounts of low grade thermal energy were being used during the day when it could be made available from the sun.

Mr. H. Brown closing the session, commented that, à propos what Dr. Stairmand had said earlier, Dr. Marshall the Chief Scientist of the Ministry of Power in his report on Research and Development, which was currently being used as a discussion document, emphasised that the increase of efficiency in all branches of fuel utilisation in industry and the domestic field was equal to finding a new source of fuel. This was what Mr. Brown was spending his life doing - increasing the efficiency of plant. There was tremendous scope. At the same time, he felt that the discussion and papers had shown that other sources of energy had to be looked into to contribute to what was becoming an ever increasing problem, not only in the United Kingdom, but throughout the world.

SESSION 7

THE DISPOSAL OF TOXIC AND RADIOACTIVE WASTES
Dr. D.H. Sharp

Dr. D. Purves (Head of Dept. of Spectrochemistry - Edinburgh School of Agriculture) opening the discussion, was intrigued by some of the things Dr. Sharp had said and fascinated by the concluding remarks in his paper - 'given a stable society and a continued technologically based civilisation, the storage and ultimate disposal of radioactive waste will present no particular problems'.

He doubted whether we were justified in making either assumption. At the present time, our society did not look particularly stable - there was a general feeling that there was something wrong with our economic system and there was increasing agreement, within informed scientific circles at least, that our technologically advanced society could go on the way it is doing. It was dependent upon the use of a wide range of metals and as the global reserves of metal ores were being exhausted rapidly, it had been predicted that these reserves could not last much longer than a few decades if present trends continued.

Dr. Sharp had mentioned the 12 stainless steel tanks in which concentrated liquid radioactive waste was contained at Windscale. He was very glad that Dr Sharp was optimistic that some other method of storage would eventually be found because there would be no nickel to make stainless steel after the half life of some radioactive materials had expired. Plutonium was listed as having a half life of 24,000 years. Nickel ore reserves were estimated to last no longer than the year 2000 if consumption continued to rise at its present rate.

Dr. Purves had also been very interested in Dr. Sharp's remarks that the emission of sulphur dioxide from a 1000 megawatt fossil fuel power station might amount to 90,000 tonnes per annum. Dr. Sharp had weighed this sulphur dioxide emission against the creation of $7\frac{1}{2}$ tons of concentrated highly active radioactive waste from a comparable power station. The difference in weight was most impressive but he did not think it was very meaningful. We needed $7\frac{1}{2}$ tonnes of radioactive waste about as much as a hole in the head and while it was undesirable that vast quantities of sulphur dioxide should be emitted into the atmosphere, it did provide essential sulphur for the present agricultural system. It seemed absurd that we had actually become dependent upon atmospheric pollution with sulphur dioxide for the supply of sulphur as a nutrient element. Modern synthetic fertilizers contained practically no sulphur and agricultural production would probably have been seriously affected if it had not been for the atmospheric pollution with sulphur dioxide at the present time.

However, his own particular interest was not in sulphur or radioactive waste, but in the overall process of dispersion of metals in the environment and he wished to say a few words on this to complement Dr. Sharp's excellent paper.

As environmental contaminants, metals were quite unique in that, unlike radioactive and organic waste, they were never broken down. And, once they were dispersed in the environment, they would remain there for ever. He wanted to take a short global glimpse at man's use of metals. Metal ores were extracted from finite localised deposits in several parts of the world. Metals were then refined from these ores to produce the metallic objects our civilisation required - anything from a drawing-pin to the Eiffel Tower. When we had finished with the metallic objects, we threw them away and they became compounded with the various kinds of waste materials we produced. The main process going on was one of dispersion of localised, irreplacable deposits of valuable metals in the environment. The metals were ultimately dispersed in the soil or in the ocean, and it had to be borne in mind that several of these metals, notably cadmium, mercury, lead and nickel, were highly toxic to plant or animal life. There were of course a number of routes of dispersal - emissions in smoke and fumes into the atmosphere, the discharge of industrial

effluents into water courses or coastal waters, the disposal of solid, industrial waste, dispersion taking place as a result of corrosion, etc. The whole object of the disposal exercise was to convert irreplacable metal resources into environmental pollutants. Once this object had been achieved, there would be great difficulty in recovering the metals - the difficulty of recovery went up very markedly with the extent of dispersion. Our descendants would be able to find any nickel or chromium to continue replacing the stainless steel tanks used for containing radioactive waste. He had no desire to be a prophet of doom, but nor did he share the view of the successful industrialist who stated "what has the future ever done for me?" We had to think about future generations, we had to try not to mortgage their future. It seemed to him that the problem was not essentially one of finding sites for land disposal of noxious and toxic wastes, but of finding ways of recycling the resources which the wastes represent, in particular the metal resources. He believed that recycling was the key to the problem of waste disposal in the long-term, and although Dr. Sharp in his paper had taken a short-term, sensible, practical view of the problem, he said he would be very interested to hear during the discussion whether Dr. Sharp agreed with this opinion, and would like, in particular, to ask him what he thought of the pyrolysis process as a possible means of disposing of solid waste on a large scale.

Dr. D.H. Morley (Nuclear Safeguards Dept. South of Scotland Electricity Board) speaking as the second discussion opener, said that Dr. Sharp had reviewed a number of the legislative controls that were involved in the use for man of radioactivity. He wished himself to speak on how a utility such as the SSEB which was responsible in its activities for the production of quantities of radioactive waste, operated the requirements of the controls which had been set up. The SSEB owned and operated, as was fairly well known, two nuclear power stations within the one licensed site at Hunterston in Ayrshire. Hunterston A was a magnox station which had been in operation since 1964 and Hunterston B was one of the first commercial Advanced Gas-cooled Reactors which had been operating successfully at power since February 1976. From neither of these stations was it possible for the Board to dispose of radioactive waste except with the possession of and within the terms of authorisations granted by Central authorities. The wastes arose as gaseous, liquid and solid. Taking gaseous first, he said that the authorisations at Hunterston A required that the BPM should be found to minimise the discharge of such wastes. The activities arose mainly from air cooling of shields and from occasional planned depressurisation of reactors. The requirement to use BPM was seen by the Board as a continuing commitment and steps were taken to review and improve methods of minimising discharge which at a station such as Hunterston A, was mainly by filtration not by delay. For Hunterston B, interestingly enough, although the authorisation was in the same set terms as in Hunterston A, there was a requirement given to and accepted by the Board, to minimise its discharges to 1/20th of a derived working level - that was to say the effect the discharges would have on the most exposed members of the public was a dose of 5% of that which would be permitted under international and national regulations. This requirement was translated into an operating restriction or an operating instruction for the Hunterston B operators. The effects of discharges were monitored by district surveys around the sites and the results of the surveys which were carried out by the Board were made available to local authorities.

On the subject of liquid wastes he said that the terms of the authorisations were similar in an essential way in both Hunterston A and B, in that the authorisations reflected the quantity of wastes arising which the designers predicted might have to be dealt with. Liquid wastes arose principally from treatment of nuclear fuelling ponds and also due to production of tritium from activation of an impurity within the graphite. With continuing discussion and the build-up of expertise within the authorising authorities together, it was known that the activity in the liquid effluent which the Board were authorised to discharge was probably an equivalent of 1% or less of that required to result in one derived working level although the limitations were not described in that manner. The

effects of the discharges were monitored again in part by district surveys, the results of which were made available, but there were also external authorities who carried out monitoring on a wider range than the immediate environs of the station.

On solid active waste he had to say first that the waste which was generated by for instance the activation of in-reactor products, control rods or thermocouple wires, was not disposed of as such at this stage. It was accumulated on the site, under one of the many conditions applied to the nuclear site licence which was granted to the Board before first construction and then operation of the station could take place. The terms of the conditions were issued by the Nuclear Installations Inspectorate. The solid waste he had just described would accumulate on the site during the life-time of the power station and the design of the bunkers or storage spaces was such that the waste could, at some stage, be retrieved for final disposal. In passing he wanted to say that there were other authorisations to which the Board might have or had had use. Very lightly radioactive waste had been authorised for discharge to the Drigg disposal centre in Cumbria. There was access, if required, to sea-dumping of certain wastes arising from fuel cooling in the pond and the SSEB had an authorisation for the discharge for lightly radioactive oil from the stack of one of their Coal Fired Power Stations. Dr. Sharp's paper had emphasised the re-processing of nuclear fuel and its separation in part into radioactive waste. This was not a direct function of the utilities, but they were aware that the fuel cycle completion had an effect on the economic and statutory requirements on the Board and, therefore, were interested, for example, in the timing of any additions or replacement of plant at the Windscale Reprocessing Factory, and had made some financial acnowledgement for the probable vitrification of the waste that had been produced from the fuel that had been returned to Windscale already from Hunterston A.

The authorisations in Scotland until a short while ago, had all been granted to the Board through the Agency of one Inspectorate - HM Industrial Pollution Inspectorate in Edinburgh, although it was known that they consulted various other bodies in order to come to their authorisation terms. The exception was that the Nuclear Installations Inspectorate, since the beginning of 1975 did not report directly to the Secretary of State, but to its own Commission.

Finally in his outline of a factual account of how the problem, or the challenge of radioactive waste management was being dealt with at the SSEB, he had been intrigued and pleased to see in Dr. Sharp's paper to such an important occasion that problems in radioactive wastes management were presented in perspective as part of a picture in which reference was made to other sorts of waste including toxic wastes to which we were exposed. And the first report of the Committee on major hazards had been very percipient, it had been out only for a short while but its thoughts on the possible licensing of sites other than nuclear licensed sites were very intriguing.

He hoped that in his brief period of introduction he had shown that the SSEB were happy to, and thought that they did live reasonably well with the Act - in this case the Radioactive Substances Act. Dr. Sharp's comments on the great deal of research and development into the effects of radioactive wastes had been pertinent. He agreed with his comments on the safety record and agreed further with the Royal Commission on Environmental Pollution, that in radioactivity there was no other example where the hazards had been better identified. He looked forward to further discussions and questions.

Mr. D.B. May (Exeter City Council) questioned Dr. Sharp on the carriage and disposal of hazardous wastes, with reference to the Code of Practice of the Streatfield Working Party. Speaking as one who was wary of cowboys masquerading as specialists, he asked what certification was reasonable of approved carriers? Secondly, he asked what training was available for personnel, to ensure that

they knew how to conform to good practice? His third point was that producers should properly certify their wastes. Many wastes were mixtures and it seemed that their actual content was uncertain. What, he asked, did Dr. Sharp understand by the phrase 'properly certified'? The Code specified that appropriate precautions had to be taken by carriers. He asked what identification code Dr. Sharp preferred for carriers vehicles? Was it likely that we should have a standardised code in the near future? The code further stated that disposal site operators should provide full information to producers and carriers. He wondered what Dr. Sharp considered to be 'full information'. Finally, he said that if specific lists of hazardous materials, such as EEC and Key Committee lists, were included in codes of practice or directives, how would new hazardous substances, yet to be produced be included in such directives?

Prof R.S. Scorer (Environmental Lobby) Prof. Scorer said that he was an environmentalist and did not like to be categorised with a miscellaneous collection of well intentioned but misguided crackpots, including many in the EEC and EPA, as the Environmental Lobby - as if all could be dismissed for the faults of some.

He supported all that Dr. Purves had said, stressing that we ought to think in the long term and forget what someone was alleging that the community thought it wanted now. In that context, a want was a wish, especially if it was an offered alternative: it was in no way a requirement. He thought that the discussion of radioactive waste had been conducted as if a decision had to be made now, but supported Prof. Walton, of Imperial College, who held that all such waste should be accessible and above ground, the responsible thing to do, until the long term issues were much clearer. The waste might well turn out to be useful afterall, and as valuable as many of the metals we were in danger of running out of.

Prof. Scorer had noticed fluoride in the key list shown by Dr. Sharp. He said that there was a lesson to be found there: in the last two or three years fluoride had officially become a nutrient and was alleged, without any satisfactory evidence to back up the statement, to be good for teeth. Some people even went so far as to say that this was part of a plan to get rid of a noxious waste by diluting it into the water supply. What he complained of in this was the change in the use of words in order to further a policy without any change in the evidence. He felt that this ought to be regarded in the case of many new processes introduced because of Departmental policy. More frankness and discussion were needed. In local government it was accepted that a plan cannot go forward unless the elected members were persuaded of it. He thought this should be true of nuclear energy, fluoridation, and a great many other things. He disagreed with the policy of maintaining secrecy where it was thought that the public would not understand and considered that we should not proceed until we had persuaded the majority of those who wished to think about a matter.

He emphasised the great responsibility owed to posterity. He thought that we should remind ourselves that we were using up resources now for so-called peaceful purposes faster than at the height of World War II when we had been desperate and destruction had been organised. It became a very serious indictment when we knew it could not last more than two or three decades longer. He said that Environmentalists were concerned about a very serious matter and that we should never be rushed into agreeing to a technological solution to a problem on the say-so of the experts who asserted that we "must" have it.

Mr. George Stott (Scottish Development Department) commented that formal authorisations were required by anyone wishing to dispose of radioactive waste. In Scotland the Scottish Development Department was the authorising department while in England and Wales the Department of the Environment was the principal

authorising department. Fuel elements were reprocessed at Dounreay in Caithness - all fast reactor elements would be reprocessed there. Dr. Sharp had asked whether we were reducing or adding to the world's radioactivity. There had recently been an article by Cohen in Nuclear Engineering International which argued that by using uranium we were reducing the radioactivity available to man (in particular by reducing the Radon levels) provided that our high active wastes were concentrated and disposed of in geological formations.

The important factor in 'glass' making (in solidifying radioactive wastes) was that the leach rate of the radionuclides in the glass should be extremely low.

Prof. Scorer had raised a point about the public not being informed on Nuclear Energy. Information was available to the public at Public Inquiries and the SSD did try to inform people as much as possible. For example there had been Public Inquiries at Torness and Chapelcross in the past 2 or 3 years.

Mr. T. Henry Turner (Individual Member) said that Prof. Scorer had defined the sort of individual member he was. He himself spoke as an old metallurgist. Comments about humanity using up the resources of the earth's crust had reminded him of 1924 when Sir Thomas Holland had given warnings about that. Two years later experts had been employed to find uses for a superabundance of nickel. Rare troubles through toxicity of nickel compounds ought not to make us forget that nickel alloys used in food processing machinery had prevented much waste of milk and foodstuffs. In steam turbine blades nickel alloys had saved wasting millions of tons of coal. In gas turbines they had saved millions of hours in the air being wasted.

He remarked that Dr. Sharp's 90,000 tons of SO_2 from the big electricity generators seemed frightening but that half of it was oxygen and the sulphur was needed by plants and animals and perhaps the sum of mass and energy still remained constant.

His conclusion was that for humanity preservation was as important as production. The poorer 'third world' got spades, axes, hammers and tractors at the expense of the Western industrial countries polluting air, water and soil. Was it not better to concentrate on the prevention of waste by constant active materials preservation and to prevent people making litter rather than filling the environment with all kinds of litter bins.

Mr. J.T. Hague (West Derbyshire D.C.) said that he came to the rostrum feeling a little out of his depth in the subject, but he had found the paper given by Dr. Sharp informative, and also the contribution by the two discussion openers.

It had occurred to him to ask how responsible were the other countries in this field? The UK seemed to be a little more concerned about how the list of wastes drawn up by the Key Committee compared to the EEC list.

He asked whether there was a World Watchdog Committee or could it be possible for an irresponsible country to dispose of its waste, whether by land, sea or air, and contribute to Global Pollution? Could accidents happen?

Mr. H. Brown (Consultant) said that he was not competent to assess the Comparative toxicities of 7½ tons of radioactive waste compared to 90,000 tons of sulphur emitted from combustion processes.

It had been inferred however, in the opening of the discussion, that SO_2 in the atmosphere had suddenly become essential to our agricultural scenario due to the fact that it was not now present in artificial fertilisers. He hoped that

this might have been over-stated in view of the fact that the NSCA had continually campaigned for a reduction of SO_2 emissions. He suggested that sulphur should be applied to the land in a controlled fashion and not by haphazard non-selective fall-out from plumes which might or might not pass over agricultural land.

He commented that as North Sea Oil contained much less sulphur than the fuel oils used hitherto it would therefore seem that the position would soon be altered dramatically, for a short period at least, and he trusted that our agricultural scientists were studying this trend which might cause them dismay but which would give satisfaction to members of the Society.

Mr. K.L. Sehgal (DOE WHO Fellow) said he was an engineer in the Environmental Office of Planning and Design in an industrial town in India, which contained about 14,000 small and large scale industries. They had experienced problems of toxic liquid waste from the cycle industry and the wool-dying industry. The waste from the industries was discharged into a stretch of water about a mile long, and had been collecting there for two or three years past. The leaves on the trees alongside the water had withered, and some of the birds and cattle which drank from that stagnant pool had actually died. So the problem there had been very serious. The Water Pollution Control Act of 1975 (India) had given the Environmental Officers vast authority to control pollution of this nature. The tolerance limits in his city were now set at the legal standard specifications, and cycle and wool-dying industries had been forced to treat their liquid waste to those specific standards, so that the problem was not being continued as before. His concern was that if the accumulated solid waste was toxic, how should it be disposed of? Dr. Sharp had said that industries had to ensure that toxic waste was correctly disposed of and he wished to know if Dr. Sharp had any standards for permissable limits of chemicals in solid toxic waste which could be adopted in his city and forced on the industrialists, so that they should analyse their wastes and treat them to a required standard.

Miss Mary McClintock (Friends of the Earth) asked whether Dr. Morley could make a few comments on the South of Scotland Electricity Board's proposal to mine Uranium in the North of Scotland and Orkney, and what arrangements had been made to dispose of the radioactive tailings in those areas? What effect would the dust have on the farm animals and fish?

Dr. Sharp had made no mention of the social controls that would be necessary to organise waste disposal. Did he conclude that this would not damage the community?

On the subject of Public Inquiries and public interest that Mr. Stott had mentioned, she commented that perhaps if more notice of such developments were given to the public they would have more time to consider the problems and consequences of Nuclear developments. It was not easy to arouse public interest in six weeks.

She concluded that in spite of all the safeguards surrounding reprocessing of radioactive wastes, it was ironic that the safety warnings at Dounreay said "In case of criticality - RUN".

Dr. D.H. Sharp wished to reply first to Prof. Scorer. He had not intended that his use of the words "environmental lobby" should be in any sense derogatory - he was himself a member of it. He had merely used the phrase as a convenient shorthand, recognising that it covered a wide variety of people with varying views.

A number of points had been raised about the practicalities of what the waste disposal business was all about and he was grateful that they had been raised. He thought Mr. May had posed some very pertinent questions indeed, which really

highlighted some of the points he had been trying to make in his paper - that in a perfect world the composition of all wastes would be known, they would be properly transported, properly labelled, and properly handled by people who knew how to deal with them. But we did not live in a perfect world and Mr. May was, of course, quite right to draw attention to some of the many imperfections. The Streatfield Committee had found that as far as they could ascertain it would be perfectly legal for people to transport cyanide waste in cardboard boxes in open cars to waste disposal tips, if they were so minded. They had recommended the proper labelling of wastes. Mr. May had raised also the great difficulty of standardisation of labelling; he had mentioned the "Hazchem System" which he thought was quite good but what worried him about the whole matter was that too often, in a major incident, the vital information needed to deal with it would be destroyed or a notice rendered unreadable. It could be necessary to ring a number in Widnes, say, when the man concerned might be having his lunch; alternatively at 2 o'clock in the morning when most accidents seemed to happen, no one would be available. It was therefore a very, very difficult point and he did not want to suggest that we had reached anything like perfection in dealing with it. He thought Mr. May had been very wise to raise some of the many problems that did arise and that quite often, as he had pointed out, the precise composition of the waste was just not known and it could well contain hazardous material.

The question of dispersion of metals had been raised and a general question asked about whether we were running down our energy sources. Dr. Sharp stated that, of course, by the second law of thermodynamics we were. All waste energy was turned to heat, and it was either radiated into space warming up the earth so that ultimately the polar ice caps would melt and the whole of Holland would be inundated. The long term effects simply were not known. He felt that the whole ecology of the biosphere required a most careful study since we just did not know the long term effects of what we were doing.

On the question of re-cycling, he was personally convinced that the ultimate solution to conserving resources did indeed lie in re-cycling of materials, particularly of metals. Whilst it was true that no metal was ever lost in that most metals were oxidised and reached the soil or the sea from where in theory they were recoverable, unfortunately their recovery, by our present knowledge, required the expenditure of enormous amounts of energy. It was also true that we were running down our resources at a fantastic rate - that we should within two generations use up the whole of our oil resources which had taken millions of years to lay down. This was certainly true and he was certainly a member of the environmental lobby in pointing it out. He wished also to point out that if we really wanted to deal with the problem of conservation we should have to change the whole of our way of life. He thought that he had dealt with most of the points that had been raised; he preferred that Dr. Morley should be allowed to deal with the questions of nuclear resources. The Radioactive Substances Act of 1960 had been mentioned and a comment made that he had not included it in his paper. He had said when introducing the paper that he had had to be selective but it so happened that he had been, as a matter of some slight interest, involved in a Committee dealing with the Radioactive Substances Bill on its passage through Parliament and they had managed, at the report stage, to amend the Bill so that the registration of all school laboratories as places where radioactive substances were kept (standard potassium hydroxide reagent) was avoided.

On the very important question of the alleged secrecy surrounding so much of this activity and particularly in the generation of nuclear energy, he said that it had to be accepted that this was a very difficult problem. Inevitably the experts and the technologists tended to be driven onto the defensive. The great difficulty, as had so often been seen was that facts, and particularly facts taken out of their context, could be grossly misleading. He was reminded of the time during the war when Leyland Motors of Leyland had been turning over their production to tanks. It had been announced in Parliament at one stage that the output of tanks from Leyland Motors had been trebled within six weeks. This had been quite true - three tanks had been produced instead of one; the facts had been correct but

misleading. What he had tried to do was to put the facts about nuclear wastes disposal into perspective. Sometimes on the radio and television facts were presented about the disposal of nuclear waste that were definitely misleading. That the quantities involved were really so tiny and that the radioactivity associated with the waste was so small, relative to the background, were rarely mentioned in public discussion.

Dr. D. Purves said he certainly agreed with Professor Scorer that it was necessary to take a long-term view, and that instead of thinking in terms of disposing of toxic waste we ought to be thinking in terms of re-cycling. We ought to consider what it was that constituted a toxic waste. A waste would be toxic either because it contained a high concentration of a toxic element, usually a metal or some organic compound which was toxic. It was possible to de-toxify waste materials by destroying the organic compound and it was possible to recover the metals and eliminate the toxicity in this way. So that for the future the possibilities of pyrolysing large quantities of toxic waste ought really to be investigated. Where he disagreed with Prof. Scorer was that fluoridation of public water supplies was a means of disposal of a toxic waste material. He did not think that this was true and he thought that Prof. Scorer weakened his own position by making such an assertion. Fluoridation of the public water supply was one of the most conspicuously successful public health measures that had ever been devised. He certainly agreed with him that there ought to be more public debate and then there would be less superstition about the matter.

The last point he wanted to make was that he agreed of course with Mr. H. Brown that it was absurd that we should be dependant on atmospheric pollution with sulphur dioxide for our supply of sulphur as a nutrient in agriculture. The sulphur ought to be included in the fertilisers which we used.

Dr. Morley had been disappointed to hear Prof. Scorer's comments about secrecy surrounding the work involved in the production of nuclear power, and that the position had not been explained to the general public. This was certainly not due to any reticence on the part of the Electricity Boards in this country, and he could give some examples to prove this. There was an open door policy for visitors to go around Hunterston Power Station where they had the opportunity for discussion with members of staff. The important thing to be considered in this case was that twelve years after the start of Hunterston A there was still a good deal of demand for this sort of learning experience. Addressing himself to Miss. McClintock, of Friends of the Earth, he said that the Torness and Chapel Donan's sites had both been subject to public exhibitions organised by the Board. This had involved SSEB people going to Dunbar, and Girvan to be available to speak in a relaxed manner and at length to any member of the public who had come along with queries. As far as he knew, both exhibitions had been fairly well publicised and he also recalled that the one in Dunbar was in February of '74, and the public inquiry was in June '74. Exchanging a word with Mr. Stott of IPI, who had said that Torness as an SGHWR might or might not be built, Mr. Stott might or might not be correct, but Dr. Morley said that the SSEB's continuing policy was to press forward with its plans to start to construct at the appropriate time two x 660 megawatts SGHWR Units at Torness.

Replying specifically to Miss McClintock about the possibility of mining uranium ore concentrates from the North of Scotland, he remembered one news incident. There had been a Friends of the Earth News Sheet which he thought had been published in Orkney, which had identified a site and had been concerned about the possibility of mining there. He could state that if mining were to start there then the controls and the regulations that the Board would expect to be applied would be similar and as effective as those applied to other nuclear activities. A reply had been sent shortly after this News Sheet had been read, to the effect that the SSEB understood that the total quantities of mineable uranium in the

whole of the North of Scotland was small and of low grade. In an additional note, Dr. Morley stated that the Board was taking an interest in the establishment of further reliable data on uranium deposits in the area by means of exploration.

INDEX TO SPEAKERS

43rd ANNUAL CONFERENCE

EDINBURGH

11th - 15th October, 1976

AIR POLLUTION CONTROL :

THE RECOMMENDATIONS OF THE ROYAL COMMISSION

of

Sir Brian Flowers, FRS
Imperial College, London

National Society for Clean Air
136 North Street
Brighton BN1 1RG

When I last spoke to you on 3rd July 1974 the Roayl Commission's study of air pollution control had just begun, so I talked to you about the general background to the Commission's work. I also mentioned our study of the environmental aspects of the nuclear power programme which had begun a little earlier. The history of how we came to undertake two major studies simultaneously is itself an interesting story: with hindsight we perhaps attempted too much, but all I will say about it now is that as the two studies progressed side by side we learned a lot that was relevant to each from the other. The outcome of both our studies are now published in the Fifth and Sixth Reports; together with the Fourth Report they complete the present phase of our work, and in particular my own contributions to the Royal Commission. Much, however, remains to be done and I am sure that the new Chairman, Professor Hans Kornberg, will bring to its work fresh vigour and new insights.

I joined the Commission not quite sure whether there was need for it to continue in existence; whether Lord Ashby had not completed the job. After all, there was by the time he left a Department of the Environment, and at least the promise of a Pollution Control Bill. I leave the Commission, however, convinced that it must continue for a long time to come: to examine issues that otherwise would be ignored, or conveniently suppressed, or which fall between several stools, or which are dominated by vested interests - or which have simply not been scrutinised independently for a long time. All these considerations have been present in some measure in all the matters we have studied, as I am sure will be the case in future studies. May I therefore wish Professor Kornberg well for all our sakes!

In our Fifth Report, "Air Pollution Control", we recommend that responsibilities for the control of industrial emissions to air should continue to be shared between local authorities and the national inspectorate, the latter concerning themselves with the more difficult industrial processes. We considered that "the best prospect for a continuing reduction of difficult industrial emissions lies in the constant interaction between these industries and an informed, national control authority. A national authority is needed to deal with the technically difficult problems with which local authorities cannot cope. We have no doubt that the general transfer of the Alkali Inspectorate's control responsibilities to local authorities would be undesirable. These views are based on consideration of the position as a whole. We recognise that some local authorities may already have staff with the technical qualifications and experience that would enable them to assume responsibility for controlling emissions from some registered industries: and that, as a consequence of local government reorganisation and the formation of larger authorities, this trend may be expected to continue. We recognise too, the force of the argument that so far as possible there should be local control of matters which cause local concern.

These factors suggest the need for flexibility in allocating responsibility for control between the Inspectorate and local authorities ... However, we consider that for as far ahead as it is sensible to try to look the central inspectorate will be needed, and that any transfer of responsibilities to local authorities should be subordinate to the preservation of the technical competence of this Inspectorate."

Nevertheless, in order to ensure a greater local participation in the control of pollution from otherwise nationally controlled industries, we proposed a procedure whereby Environmental Health Officers should be empowered to act as the Alkali Inspectorate's deputies in ensuring compliance with the latter's consent conditions. "Deputy sherriffs" we called them in the language of the Wild West. And we recommended that all Environmental Health Officers should have unambiguous right to enter works under national control when they believe that these conditions are being breached. Local authorities will therefore be in a better position to know what is going on in works in their areas, and to

influence the actions taken.

We also gave very serious attention to the fundamental principles of "best practicable means" according to which the Alkali Inspectorate work. I need not describe this concept here. We reached the firm conclusion that the bpm system should be continued because it is consistent with the realities of pollution control. "In principle it provides a flexible and sensitive means of achieving the balance of costs and benefits which should be the aim of control." We were aware, however, "that precisely because of its flexibility the bpm concept can be misused. At its best the term connotes a rigorous analysis of the objectives and consequences of air pollution control. At its worst the term can be used as a catchword to conceal the absence of any such analysis. With the use of bpm should (therefore) go a recognition of the need to justify the decisions reached."

Some people have seen our Report as showing satisfaction with the work of the Alkali Inspectorate. We have indeed tried to give credit where credit is due, and there is no doubt that giant strides have been made in this country by the Inspectorate, and also by the local authorities, in achieving cleaner air without holding back industrial development. But our Report presents 94 recommendations for changes and improvements in the system and practise of air pollution control. I think that is sufficient to indicate that whereas we uphold the essential nature of the control system we are far from satisfied with its detailed application, or with its public appearance. In spite of the overall improvement in our air quality there are still too many unacceptable areas. Nobody passing on the M4 through Port Talbot could be satisfied with the grossly polluted atmosphere of that stretch of industrial development.

I cannot run through all 94 recommendations here. Instead I will remark on 3 issues that were central to our thinking. I have already mentioned 2 others, namely the need for closer collaboration between local authorities and national inspectorates, and the reduction of secrecy about discharges that this would entail.

Firstly, we made a clear distinction between emissions to air, which is what goes up the factory chimney or escapes through the roof, and air quality which results from the emissions returning to earth. Although the one is the cause of the other, the two should not be confused because the link between them may be difficult to establish especially in circumstances where the air quality in one locality may result from many sources of emission, or may be affected by topography and weather. The <u>object</u> of air pollution control is to produce an acceptable level of air quality. The <u>means</u> for bringing this about are to control what is emitted from the works and the manner in which it is emitted, such as the chimney height. We uphold the Alkali Inspectorate in their determination "to use the best practicable means for preventing the emission into the atmosphere from the premises of noxious or offensive substances and for rendering harmless and inoffensive such substances as may be so emitted." We point out, however, that this presupposes - for example, in determining the height of a chimney - some idea of the desirable levels of air quality on the ground. We do not believe in air quality <u>standards</u> as a means of control, but we have put forward the concept of air quality guidelines to indicate whether the practice of best practicable means is falling far short of what is desirable by way of air quality or, on the contrary, is subjecting industry to unnecessary restrictions. There is no paradox here: bpm is the control of emissions, and it is expected to take into account economic, social, national and local circumstances; the guidelines are intended as one of the indicators of local circumstances, viz. a measure of the air quality actually being achieved.

In no sense, moreover, should air quality guidelines - or even air quality standards - be confused with <u>emission</u> standards which have no regard to local circumstances and which are so favoured by the Commission of the European

Communities on the grounds that they provide fair competition for industry. They do indeed, but at the expense of quite unfair variations in the local environment. The polluted should be treated fairly as well as the polluter. We are thus in favour neither of uniform emission standards nor of air quality standards as the means of control: there must be flexibility to take account of local circumstances. We favour control over emissions according to the best practicable means having regard to the levels of air quality actually achieved relative to those that are desirable for the locality.

Secondly, we observed that air pollution cannot be considered in isolation: its ultimate source is some industrial process that pollutes more generally. Some people have complained that our Report went beyond the terms of reference of our study. But it did not go beyond the terms of reference of the Royal Commission which are concerned with the total effect of pollution on the environment. It would have been stupid to have proposed arrangements for controlling air pollution which might have increased the problems of water pollution and the disposal of industrial wastes or, indeed, in some cases, of noise generation or derelict land. Clean air is important, but it cannot stand alone.

In our Report we drew attention with the aid of examples to the transferability of pollution from one medium to another. "In order to reduce atmospheric pollution, gases or dusts may be trapped in a spray of water or washed out of filters. This leaves polluted water, which if not discharged to a sewer or direct to a river or the sea can be piped into a lagoon to settle and dry out, leaving a solid waste disposal problem. The pollutant may even go full circle by blowing off the lagoon as a dust. Other examples include water seeping through refuse tips, smoke from the incineration of rubbish or sludge, and pollution of land where sewage sludge containing heavy metals is used as a fertiliser". But in spite of this transferability - and even where it had been recognised - we found that there had been surprisingly little consultation between the authorities concerned with the different forms of pollution. So isolated were they, each in his own polluted compartment, that at first they refused to believe that there was even a problem. And even now I fear that the Government may be doing its best to show that the examples we picked on were in some way anomalous and that in general the problem of transferability does not arise. I believe, on the contrary, that transferability often does not manifest itself simply because, with the exception of the Alkali Inspectorate, the control authorities are concerned only with the <u>disposal</u> of pollution and not with its <u>arising</u> in an industrial process. It is in the process itself that the pollution occurs, and it is by modification to the process that the transferability arises. To control the arisings and the transferability of pollution a considerable knowledge of the industrial process is required.

A further example of the transferability of pollution arose in our Sixth Report where we remarked that the present arrangements for dealing with discharges of radioactive substances from nuclear plants may not lead to the optimum environmental solution. "The reduction of a particular discharge does not eliminate the radioactivity but merely changes it into another form. Thus, if extra filters are used to reduce an emission to atmosphere there will result a correspondingly larger mass of moderately active material to be stored or buried. Discharges to water can be treated with ion-exchange resins, but these then pose troublesome disposal problems. Burial of radioactivity on a landfall site may carry the risk of contamination of groundwater, or of resuspension of aerosols in dry and windy weather. Alternatively, if the site is revegetated, radioisotopes may be incorporated into the crops." The complexity of the problem has meant that under recent arrangements the Alkali Inspectorate, the Radiochemical Inspectorate, the Nuclear Installations Inspectorate, the Factory Inspectorate, the Fisheries Research Laboratory and the Food Science Division of the Ministry of Agriculture, Fisheries and Food, have all been involved in the control arrangements - a situation likely to appear effective and comprehensible neither

to the industry nor to the public.

It was considerations such as these that led us to propose the unified pollution inspectorate that we somewhat irreverently dubbed HMPI. I should explain in parentheses that "humpies" is a word denoting a particularly intimate activity in my family. Its job would be to use the best practicable means to reduce the arisings of all forms of pollution from particularly difficult industrial processes, rendering harmless whatever may be emitted - that is to say they should use bpm on the arisings but see that the discharges are such as to accord with environmental quality requirements as laid down by other bodies for air, water and land. Moreover, they should exert their powers in such a way as to produce the best effect for the environment as a whole, a concept we described by the phrase "best practicable environmental option". Because it is the process that gives rise to the pollution we believe that the techniques of the present Alkali Inspectorate would be largely adequate for the task of HMPI, supplemented to be sure by some additional expertise required by the wider responsibilities.

I want to emphasize, lest there be misunderstanding, that the role of HMPI is to deal with arisings from particularly difficult industrial processes; it is not to encroach upon the responsibilities of the waste disposal authorities or the water authorities. Waste disposal authorities will continue to be responsible for ensuring that wastes are disposed of in an environmentally acceptable way once they have arisen; it is the job of HMPI to assist in limiting the arisings, not to deal with the eventual disposal. Similarly, the water authorities would continue to determine quality criteria in accordance with water usage and to set and enforce compatible discharge criteria. Again, HMPI will deal with the arisings and will use bpm to help industry to meet these consents. Clearly in seeking the best practicable environmental option HMPI would need to develop the closest relations with waste and water authorities and also with the local authorities who handle the great majority of polluting sources both domestic and industrial.

We also envisage that in the future the Department of the Environment will itself determine the guidelines for air quality just as the Water Authorities determine water quality so that, in effect, it will be the task of HMPI to use bpm to keep arisings as low as is practicable and thereby to achieve environmental improvements in all sectors of pollution from difficult industrial processes. Incidentally, we included noise as one of the sectors, believing that industrial noise that extends appreciably beyond the factory fence should be brought into the picture. There is transferability here too: we cite the case of flare stacks used to dispose of inflammable gases where steam is injected to achieve better combustion and so eliminate smoke, but where the result is a great increase in noise from the flare.

I would like to emphasize that HMPI is not intended to be another huge bureaucratic encroachment upon our democratic life. It is essentially a modernised and somewhat more broadly based edition of the Alkali Inspectorate, namely a small centralised body with inspectors in the field dealing with works scheduled because they give rise to especially difficult pollution problems whether to air, water or land and giving such assistance as it can, as the Alkali Inspectorate often does now, to local authorities in dealing with their problems. One important difference there must be, however, whatever the fate of HMPI, and that is as I have already implied that in future pollution control must be more publicly accountable. This, admittedly, will take extra staff and a great deal of extra patience; but the days when the public could be regarded as an ignorable nuisance by official bodies are fast drawing to a close, and the inevitable consequence is some increase of staff which the public must be expected to pay for to deal with the publication of information and the explanation of policies and actions.

The final issue I want to deal with I have already touched upon: it is the issue

of who should be responsible within Government for air pollution control, and for the control over the quality of our environment more generally. Clearly, we all have some responsibility because we are all, directly or indirectly, both polluter and polluted. However, that does not suffice as an argument for determining where responsibility should lie in Government, even though it is sometimes adduced as such, especially by the Trade Unions.

In discussing this matter it is tempting to follow the argument of the Robens Committee which in 1972 recommended the transfer of the Alkali Inspectorate to their proposed Authority on Health and Safety, namely "that where the internal and external problems arise simultaneously from the same technical source it is not sensible to divide the control arrangements". Indeed, it seems to be merely an extension of the argument we ourselves used for the creation of HMPI to say that it is the same industrial process both that gives rise to pollution of the environment external to the factory and that affects the health and safety of its workers; one control authority should therefore deal with both aspects. This, however, is to confuse ends with means.

"There is clearly a need", we say in our Report "for liaison between the Alkali and Factory Inspectorates where internal and external air pollution arises from the same sources. However, it is in our view an over-simplification to argue from this that common control arrangements should apply. This ignores the great difference in the nature and scope of the interests of the two Inspectorates. The Factory Inspectorate are principally concerned with the protection of workers, and of the public near the workplace, from hazards arising directly from industrial processes. These may range, for example, from bricks dropped from scaffolding to a major explosion such as that at Flixborough. Though the health hazard from air pollution within industrial works is, of course, important, it is a small part of the Factory Inspectorate's responsibilities. The Alkali Inspectorate, on the other hand, are concerned solely with air pollution and with its effects on the population as a whole and on the wider environment". We went on to stress that the criteria employed by the two Inspectorates in assessing air pollution are necessarily different because of their different objectives. Indeed, we believe that both objectives are vitally important and should not become confused through being given simultaneously to a single control authority as proposed by Robens (whose terms of reference, oddly enough, explicitly excluded consideration of general environmental pollution). In particular, "The Alkali Inspectorate's proper concern is with the environment as a whole. Their policies should be evolved not as an adjunct to industrial safety but as part of an integrated approach to the control of environmental pollution." ... "The Health and Safety Commission is an essentially industry-oriented body; indeed, this is entirely appropriate in relation to its concern with the health and safety of people at work. But the interests of industry, and even of workers within industry, may often be opposed to those of the external environment."

We thus concluded that "the incorporation of the Alkali Inspectorate into the Health and Safety organisation is potentially damaging to the interests of the environment." Believing strongly in the desirability of a unified approach to pollution problems and observing that "most pollution control rests with water and local authorities in structures that are closely linked with the Department of the Environment" we urged that the Alkali Inspectorate be returned forthwith to the control of the DoE. This recommendation was made quite independently of whether or not HMPI is agreed to, but if it is agreed then the recommendation clearly carries even more force.

There are many other recommendations in our Fifth Report dealing with such important issues as domestic smoke control and the interactions between planning and pollution. Although I have had no time for them today I would like to emphasize that in the minds of the Commission these are of great importance also.

I suppose you could say that if there is a single theme to all our work so far (including the first three Reports under the chairmanship of Lord Ashby) it is that it is time we had a Department <u>for</u> the Environment instead of a Department <u>of</u> the Environment. I mean that we need to know that there is a Department of State whose sole job it is to put the wise management of all aspects of the environment first. Many of our proposals are intended to have this effect, because we insist that environmental control should be the responsibility of the environmental departments, not of the industrial sponsorship or employment departments, still less of the CBI and the TUC. It is why in our Fifth Report we recommend the return of the Alkali Inspectorate to the control of the Department of the Environment, and the larger role of HMPI; it is why in our Sixth Report we insist that environmental aspects of the nuclear power programme, including radioactive waste management, should be under the control of the environmental departments. And it is clear to us that in spite of the doctrine of indivisible Cabinet responsibility for Governmental decisions, some way has to be found for bringing out into the open the different, and often conflicting, considerations which enter into a final decision at least insofar as they affect the environment.

The time is fast passing when it was sufficient that a new technology was feasible; in the future it will have to be environmentally and socially acceptable also. This may mean a more open form of government than we have yet attained in this country.

43rd ANNUAL CONFERENCE

EDINBURGH

11th - 15th October, 1976

ENERGY SOURCES: WHAT ARE THE ALTERNATIVES?

by

Dr. J.C. McVeigh, MA, MSc, PhD,
Head of Department of Mechanical and Production Engineering
Brighton Polytechnic

National Society for Clean Air
136 North Street
Brighton BN1 1RG

Introduction

It is now generally accepted that the exponential growth of energy consumption which has been experienced for many years in various countries of the world cannot continue indefinitely and that we must shift the emphasis in the use of energy from the "more is better" attitude to "enough is best". The conventional fossil fuel sources of energy have limited finite lives and by the end of this century the North Sea oil and gas industry will be declining very rapidly. This paper reviews the major alternative non-polluting sources of energy, particularly concentrating on wind power and solar energy.

The Secretary of State for Energy organised a National Energy Conference on the 22nd June this year. To those of us who have been working in the field of alternative renewable energy sources and who believe that the wider issues of the future of our society should be discussed openly, this conference was extremely disappointing. Almost every speaker represented a particular vested interest and with very few exceptions the possible contribution which wind and solar energy could make in the future were dismissed as being irrelevant. For example the statements issued by the South of Scotland Electricity Board in their paper which they submitted to the Energy Conference can only be described as inaccurate and ill-informed. Solar energy was dismissed in six lines, but worse, in a comment on wind power which they considered to be a small source, they stated "the contribution to the energy demand in this country is likely to be a fraction of one per cent". In March this year the Electrical Research Association gave evidence to a select committee in the House of Commons, which was reported in the press: "scientists are experimenting with giant windmills which could generate up to ten per cent of the country's electricity and they could be working within ten years - the scheme is suggested by the Electrical Research Association which hopes that 1,500 windmills will be built." Scotland has one of the best wind climates in the world and, at present electricity costs, windmill systems could pay for themselves in less than three years in many of the islands off the west coast.

Every domestic solar heating system which is installed in the country reduces the annual fuel bill of the householder. The actual amount depends on the type and size of the installation and how it is used, but the majority of installations will save well over a thousand kWh, or units of electricity, annually. The savings from larger units such as swimming pool heaters or systems for industrial process heat such as laundries would be much greater. Each system reduces our dependence on imported oil and also indirectly saves other essential sources such as water which would otherwise be used for cooling in the power stations. Perhaps we ought to get away from thinking in conventional financial terms and consider doing something which benefits the country as a whole by making the decision to install solar heating now.

Turning to energy conservation, it is interesting to see that the latest values for the standard of home insulation for the UK, which are the highest they have every been, are exactly the same as the values achieved for hundreds of years by typical crofters' cottages in places such as the Outer Hebrides.

Conventional Sources of Energy

One of the major problems created by conventional sources of energy is the various forms of pollution associated with them. Chemical pollution producing smog, radiation pollution and dust producing silicosis are well known. Less frequently mentioned is thermal pollution which may be the most important. There is an annual balance between the energy the earth receives from the sun and the energy that is re-radiated from the atmosphere. In digging and burning the fossil fuels from within the earth's crust, the atmosphere is heated above the natural balance and its temperature is raised, thus altering the climate.

In the UK, coal, oil and natural gas are the three primary sources of fossil fuel. They have this in common - they are finite in their availability, they are transportable, they are thermally polluting and are anti-socially won. They differ in that coal has the largest resources - perhaps several hundred years at present levels of consumption - and is the least strategic source. Both oil and gas are vulnerable to outside influences and coal and oil have a by-products industry which has been widely underexploited in the past. Coal is the only one of the three which is likely to be available in considerable quantities at the end of this century.

The nuclear engineering industry has a tremendous amount of political backing. For example, the Chairman of the UK AEA has recently said "There is no doubt at all that we are going to require a very substantial nuclear programme for electricity generation and we must do what is necessary to achieve this objective". However, he conveniently over-looked the fact that uranium resources are disturbingly low and man-bred plutonium is disturbingly toxic and must be internationally transported and accumulated in a world of increasingly assertive nationalism.

Alternative Sources

Today the consideration of alternative energy sources is resuming its philosophical progress after being interrupted by the first Industrial Revolution. In the interim, some 250 years of technology have been established. These "new" technologies can be applied to the elements of sun, wind, earth and water with dramatic results. The primary flow of energy-giving life comes from the sun and many of our additional requirements stem from a need to supplement its light and heat when and where there is least of it. We therefore start with a fundamental mismatch between our energy demands and the supplies which we can obtain from the sun. Vast quantities of solar energy are available but of low intensity and very variable when most needed. The intensity of radiation at the outside of the earth's atmosphere is 1.35 kW/m^2. By the time this radiation has reached the earth and been scattered by dust and water vapour the maximum intensity is perhaps 1 kW/m^2. In the United Kingdom, for example, averaged over a whole year the intensity works out at 105 $Watts/m^2$ although at the peak period of the year from May through to September the average daily solar radiation experienced in the UK is about as good as anywhere else in the world. Overall our radiation climate is perhaps half as good as that of the best countries. The present world's annual energy consumption is in the order of less than one tenth of one percent of the actual amount of energy which the world receives from the sun.

A vast secondary source of energy, deriving from solar energy, is the wind. Here in the British Isles we are particularly fortunate since the strongest winds occur in winter and wind power can be harnessed directly to provide heat when the demand is greatest.

It is interesting to look back at various points in the past century when the need for a vast programme of solar energy research has been highlighted. John Ericsson in the 1870's stated that the gradual exhaustion of the coal fields would inevitably cause great changes in international relation in favour of those countries which are in possession of continuous sun power. In an early book on solar energy, published by Pope in 1903, there is the somewhat familiar argument "The year 1902 has added an awful chapter to the history of our need of a new source of heat and power, by the wide suffering and impoverishment of the people of the eastern United States in consequence of the Pennsylvania coal strikes ....". These early pioneers on solar energy achieved very considerable scientific advances. For example, there were solar powered engines, refrigerators, house heating applications and various types of solar furnace before the turn of the century. Then the era of cheap oil and gas arrived and it was not until the early 1940's that resurgence of interest in the

utilisation of solar energy took place. Since then research workers concentrated on six main areas which have been defined, for example, in the United States solar energy programme:-

(a) Heating and cooling of buildings
(b) Solar thermal energy conversion
(c) Photovoltaic conversion
(d) Photosynthesis or biomass production and conversion
(e) Wind energy
(f) Ocean thermal energy conversion

Of these, solar water heating for domestic purposes is now available in the UK. It is still relatively expensive, however, and would take perhaps eight to ten years for an economic payback to be established depending on the assumptions made. The situation on low temperature applications for swimming pools is quite different and here, with the appropriate equipment, the payback period would be in the order of three years.

For space heating, it is difficult to apply solar energy to an existing building. A building has really to be designed with the utilisation of solar energy in mind from the start. One has only to read the admittedly limited accounts of work at Milton Keynes to appreciate this point. Solar cooling is unlikely to have any applications in the UK but has considerable export potential. One way of achieving this is by using the heated fluid to work some form of absorption refrigerator.

On the power applications, to give one some idea of the United States programme, imagine a tower almost a mile high situated on Edinburgh Castle and a field of mirrors focussing on it stretching back the length of Princes Street. Small scale solar pumps have been built on many occasions. There are two particularly interesting UK developments at present - one developed by the UK AEA at Harwell using a heated liquid principle and the other arising out of work at the University of Bristol using the properties of certain metals to assume different shapes when heated and cooled. These small engines would have particular applications, in developing countries, to water pumps. Large solar pumping systems being tested in India have raised water about 50 metres.

Direct electrical generation has attracted substantial funds for research and whereas at present it would take £10,000 for an array of solar cells which would produce, at best, 1 kilowatt, this is a factor of at least ten less than it would have cost some ten years ago and about half the cost in July 1975. It is anticipated that further research will reduce this by a factor of one hundred over the next 25 to 30 years.

The research works in the field of photosynthesis are concerned with the cultivation of organic materials and the conversion of organic wastes to produce various forms of gaseous, liquid and solid fuels. Typical investigations include the conversion of organic materials to methane gas and the feasibility of producing hydrogen from water by photosynthesising biological organisms. A further possibility is growing one's own fuel in a community development surrounded by trees. It has been calculated that four square miles of trees cropped on a continuous basis could produce enough fuel and energy for a community of up to 6000 people.

Wind

Wind power cannot be called a new energy source since it has been used for many centuries, but modern windmills, unlike their predecessors, are light, airy, structures distinguished by very slender sails. Designs ranging between 100 watts and 2 or 3 megawatts are perfectly practical by today's standards. The range of

power is representative of the requirements for both domestic heating and larger scale district heating schemes, applications in agriculture and light industry, desalination, and even feeding electricity directly into a national grid. The new generation of windmills can be provided with an automatic standby facility so that storage is not necessary, i.e. a standby diesel generator which automatically cuts in whenever there is a demand and no wind. Even at present prices of fuel it is possible to say that within two years all domestic and district sources of wind energy can be provided for all the islands of Scotland, the Isles of Scilly and perhaps within three or four years the larger islands, such as the Isle of Man and the Channel Islands, could be provided with electrical and thermal sources of energy for agricultural, desalination, domestic and district energy systems. The availability of inexhaustible energy resources to many of these sites at prices less than that of oil would transform their economies.

A recent study on the wind climate at Tiree - a small island off the west coast of Scotland - showed that a district heating wind unit of 18 metres diameter would produce nearly 500,000 kilowatt hours of electricity per annum together with nearly 200,000 kilowatt hours of hot water and that the pay-back period for these units would be less than three years at current UK oil prices. Based on electricity prices in Tiree the pay-back period would be about two years.

Geo-thermal

The earth is an almost infinite source of heat which suffers from none of the disadvantages of wind and weather. The practical difficulty is that the depth at which a useful temperature occurs depends upon how long ago there was any volcanic activity. In some parts of the world, such as Iceland and New Zealand, there are high geo-thermal temperature gradients near the surface and there may be hot water geysers available for immediate use. In the UK, where there has been no volcanic activity for over fifty million years, this is not the case. The average geo-thermal gradient is only about 25°C per kilometre. There are a few areas where slightly higher gradients have been established but there appears to be no scope in this country for generating electricity from geo-thermal methods. It is possible that geo-thermal energy could be used as a source of low grade heat for applications in process heating or for heating greenhouses. Here water could be used directly without expensive ancillary plants associated with electricity generation. The economics of this are, however, somewhat doubtful.

Tidal Power

The energy of the tides has come increasingly to the fore in recent years. The French have a scheme on the Rance Estuary near St. Malo. In the UK, the Bristol Channel appears to be a favourable site. It is not only a large estuary but it enjoys one of the highest tides in the world. Several proposals have been suggested but so far none of these have been considered to be economic. One of the potential disadvantages of the Bristol Channel scheme is that towns such as Weston-Super-Mare might find themselves surrounded by several miles of mud. The CEGB have studied the Bristol Channel project in some detail and estimate that perhaps 10% of the country's electrical power needs could be supplied by such a scheme but the economics of the whole scheme would need to be studied in considerable detail - for example, the effects of the long construction time on the overall capital costs.

Wave Energy

Wave power is related directly to wind power since waves are generated by the wind. The sea acts as a very large collecting area, while the inertia of the water provides a certain amount of short term storage which can compensate for

variations in the wind speed. Devices for extracting energy from the waves have been studied for many years and a recent design which is basically a rocking boom is being studied at the University of Edinburgh. In tank tests this particular device can extract 90% of the energy of the waves in the form of mechanical work. The advantages of using wave power can easily be seen when it is appreciated that there are large areas of the North Atlantic which are rarely frequented and could be covered with large numbers of these floating power stations. Again, in a study of the economics of wave power, the CEGB have estimated that it could well be much more expensive than conventional power generation. At this stage only model tests are being considered and there are no proposals to have a full scale trial in the sea as yet.

Energy Conservation Techniques

One of the major problems in energy conservation has not yet been widely appreciated. This is the education of those who live and work in a particular environment to ensure that everything possible is being done to conserve energy. To illustrate how difficult this is, during a recent lecture series on the broad aspects of relationships between engineers and society, energy conservation and the overall world energy situation were emphasised. All the windows in the lecture theatre faced due south and the lectures were given at 2.00 p.m. One very sunny afternoon the author arrived to find every single light in the lecture theatre was on. Not one single student had noticed this or had appreciated that this was wasting energy. Over five kilowatts were being dissipated at the time. Many buildings have double door systems to conserve the heat within open public spaces and yet these double doors are often jammed open for ease of convenience.

The simplest measure to take to conserve energy is to reduce the leakage of hot air from the building by eliminating draughts as far as possible. In general, one can say that the return in energy saved by simply sealing round windows to eliminate draughts and providing sealing strips at doors is seen in less than two years. i.e. the amount of money spent on draught sealing is easily recovered in reduced fuel costs in this period. Thereafter there is a permanent reduction in the overall fuel bill. A similar effect on windows is achieved by double glazing. Although double glazing does reduce the heat loss through a window the actual economic return does not appear for perhaps ten or more years if one considers only the theoretical reduction in heat loss, excluding the elimination of draughts. In practice, some forms of double glazing will completely eliminate draughts and there will be a dramatic reduction in the overall heat losses.

Loft insulation should be carried out. For newer buildings with cavity walls, some form of wall insulation is worth providing. In both these cases there is a fairly rapid return on the outlay and perhaps three or four years will see the entire capital cost repaid with the fuel savings.

Some of the new companies who have entered the field of solar water heating in the UK are very inexperienced and make extravagent claims about their equipment. Similar situations have also occured with double glazing and cavity wall insulation. If you have any doubt about the reliability of the company or the product please seek professional advice from a chartered engineer.

Summary

The various official predictions of future trends in our natural energy consumption are still forecasting an increasing demand.

The Netherlands has adopted a far more realistic approach with an economic model showing a gradually declining rate of increase until a steady situation is

reached by the year 2000. Perhaps the most fundamental question which should be considered now is "Do we necessarily have to relate 'standard of living' to economic growth and an increasing GNP with the accompanying inevitable increase in energy consumption or can we achieve a much better quality of life by investing in alternative sources of energy and abandoning our increasingly expensive and environmentally damaging nuclear programme?"

References

Several reviews of overall alternative energy sources have been published recently. Four of these are as follows:-

(1) Nature, 249, No. 5459, June 21st 1974. Special energy review series.

(2) Science, 184, No. 4134, April 19th, 1974. Issue devoted to energy.

(3) National Geographical Magazine, Volume 148, No. 12, December, 1975 for article on wind. Volume 149, No. 3, March 1976 for article on solar energy.

(4) The Times, March 26th, 1976 - special report on energy.

The author's book "Sun Power - an introduction to the practical applications of solar energy" will be published by Pergamon Press early in 1977.

43rd ANNUAL CONFERENCE

EDINBURGH

11th - 15th October, 1976

THE SCOPE FOR SOLAR ENERGY IN THE ENERGY PATTERN OF THE FUTURE

by

P. Brunt
General Technology Systems Limited

National Society for Clean Air,
136 North Street,
Brighton BN1 1RG.

1. INTRODUCTION

The social and technological development of man throughout his history has stemmed from his utilisation of the abundant supplies of natural energy sources which have been so easily and cheaply obtainable. The striking features of the pattern of energy consumption since the Industrial Revolution, are the increasingly rapid rate of exploitation and utilisation, together with the marked advance of energy consumption per head of population.

New fuels, far from replacing the energy resources in use at the time of their introduction, have merely been added to the available range to meet the ever increasing energy demand. This has been the pattern for coal in the 1850's, oil in the 1900's and natural gas more recently, whilst nuclear fuels are also seen to be fitting into this same pattern.

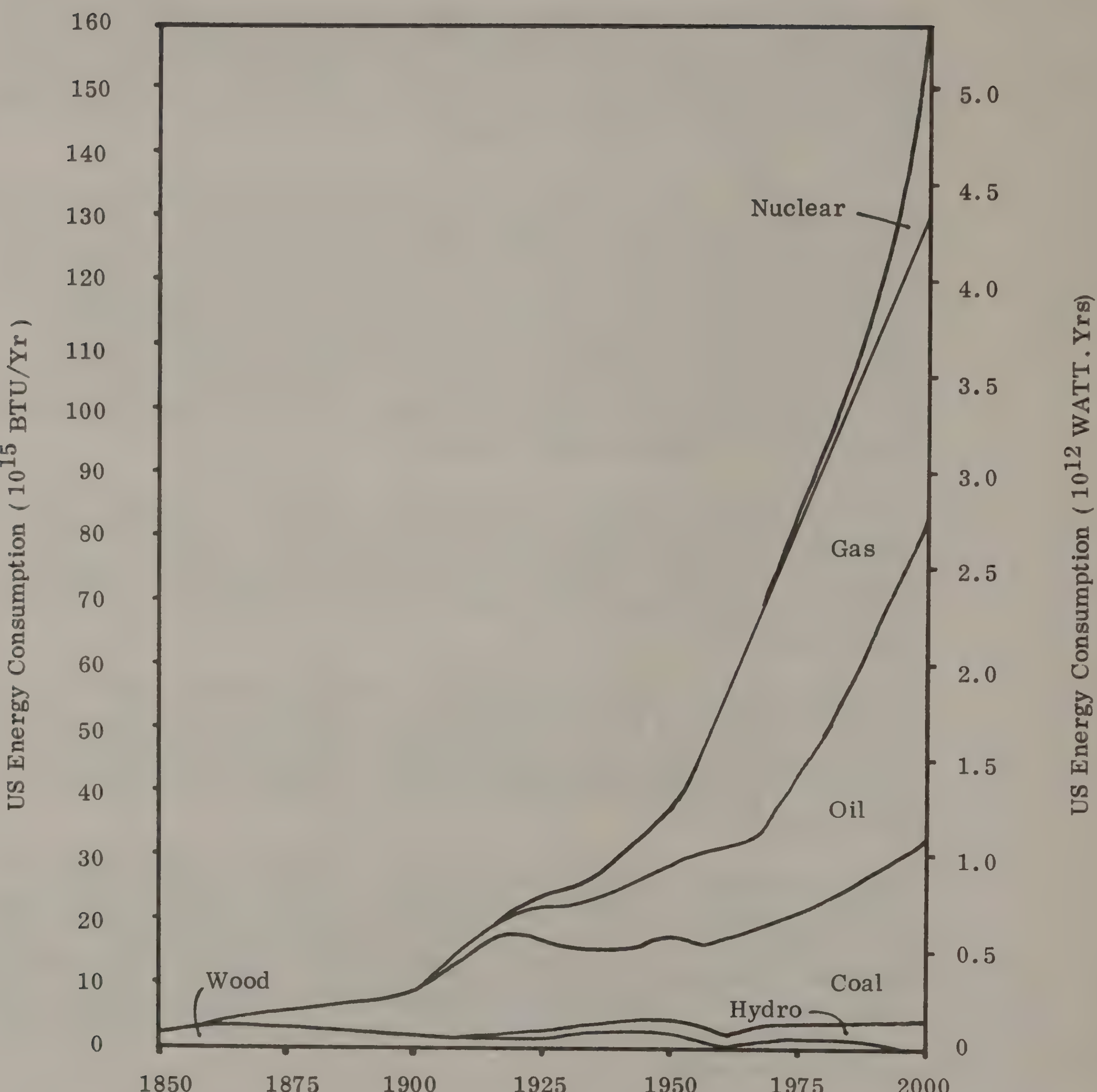
In recent years, however, it has become increasingly obvious that we face the total depletion of the Earth's supply of fossil fuels in the near future, whilst alternative means of large scale power production present grave threats to our environment. Whilst estimates vary, it is generally acknowledged that the world's resources of oil and natural gas will be used up within half a century at the present rate of consumption, Europe's coal will be gone in one or two centuries, and the introduction of nuclear fission power stations is accompanied by fears of leakage of radioactivity and uncertainty about the disposal of the radioactive waste products.

As can be seen from Figure 1, the depletion of one or more sources of energy means that it becomes necessary to increase the rate of production and utilisation of existing and new sources to make up the deficit. It remains to be seen to what degree such increase in extraction of coal, for example, can be supported.

The future energy supply situation poses enormous problems and will undoubtedly bring about radical changes in our concepts of economic growth and standard of living. For the developing, Third World countries, the problems are considerably greater owing to the rapidly increasing size of their populations.

Thus, for example, during the next thirty years the United States expects to consume more energy than it has in its entire history. Over this time span the annual US demand for energy in all its forms is expected to double, and the annual worldwide demand will probably triple. The pressure on energy supply (and prices!) will increase enormously as each nation aspires to obtain a larger share of finite resources so as to maintain and improve the quality of life for its people.

The average worldwide energy demand per person has already exceeded 3,000 kWh/year. There are, of course, very wide differences in the average energy demand from nation to nation. In the US and parts of Western Europe it has reached 18,000 kWh/year, whereas in India it is still only a few hundred kWh/year.



GROWTH OF ENERGY CONSUMPTION IN THE UNITED STATES

FIGURE 1

It is projected that the world demand for energy could rise to about 20,000 kWh/ per person per year, which, combined with projections of ultimate world population (within a century) indicates a total energy demand of 200×10^{12} kWh, some 16 times the present level!

2. FUTURE ENERGY FORMS

As fossil fuels become worked out and - as they approach this state - inordinately expensive, we must rely for our main energy supplies on such sources as Nuclear Energy, Hydro Power, Geothermal Energy and Solar Energy. So far nuclear power development has fallen behind expectations and in the EEC for example, it is unlikely to provide more than a tenth of energy needs by the mid-1980's. On the basis of present knowledge and current technical research and development, the probability is that the world will be looking to nuclear power for an increasing proportion of its supplies in the next century. The technical and commercial success of current research on large scale breeder reactors for nuclear fission and on nuclear fusion is by no means assured.

Hydro power is creating interest in some of its forms but not all countries have a suitable ocean/land interface.

Geothermal energy looks promising in the long term when the necessary "planetary engineering" techniques are developed.

This leaves solar energy which offers the following attractive features;

- wide spectrum of applications
- technology is current whilst still offering many lines of development
- in the long term, developments promise to provide major amounts of world needs
- in the short term, solar energy can effect significant savings in the consumption of conventional fuels thereby enabling them to be utilised in ways which cannot be provided by other means

If we are to be in a position where solar energy can make its contribution to the energy picture, action must clearly be taken at once - not only action of a technical nature but also in the creation of the appropriate environment in which solar energy applications can expand.

The topic of solar energy has received much attention since the Arab oil embargo and price rises following the 1973 war, but one would still look in vain for a major scope for solar energy in the energy projections of UK Government bodies. After a period of assessment of the potential of this energy form, a number of countries do see solar energy as making significant contributions to their energy budgets - many of them developing countries.

The United States' Government, after passing its Solar Demonstration Act, has provided an important impetus to solar energy exploitation in the US and is spending the equivalent of some £35 million per year in 1975/76, rising to over £100 million in 1976/77. Japan, with an expenditure of about £17 million, clearly attaches great faith to the benefits to be expected from solar energy. EEC now has a solar energy programme and so do a number of European countries though these are, even in total, relatively modest. The UK has consistently held a somewhat pessimistic view of the role of solar energy, both in regard to within the UK and in relation to overseas markets.

The purpose of this paper is briefly to examine the role of solar energy and the factors which impinge on its introduction, to look at solar developments being pursued and considered around the world, and to consider what it could all mean to the UK and Europe.

3. POTENTIAL ROLES OF SOLAR ENERGY

Solar energy can be exploited in many applications, for example;

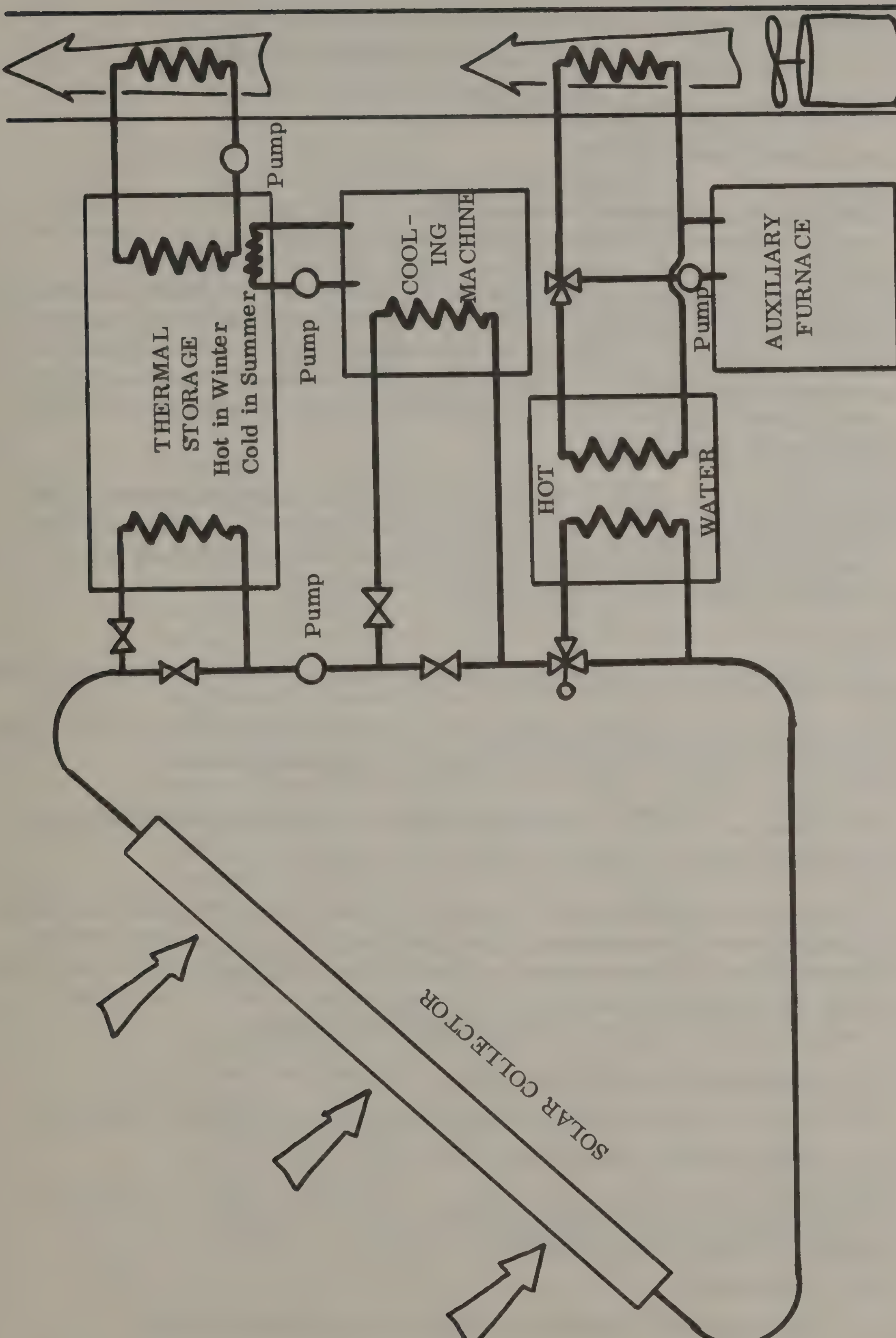
- domestic/commercial/industrial water and space heating, air conditioning (Figure 2)
- industrial processes - eg crop drying; process-water heating
- high temperature applications - eg furnaces; thermal conversion to electricity
- conversion to electricity - eg photovoltaic means
- conversion to gas - eg biological means; photochemical process

4. CURRENT AND FUTURE APPLICATIONS

The large majority of applications of solar energy are to be found in the United States, many of which are well known. A few examples of some European projects are as follows;

In the UK, the Milton Keynes house is the leading example of a serious attempt to investigate the main features of a solar installation. Whilst the house and solar equipment were not designed as a system - with resultant compromises in the solar system - this is a house in which an ordinary family is living and hence is a valid test of such a system in its true environment. The solar house is one of a group development, with an otherwise identical house providing the 'control' comparison. The solar system provides both water and space heating and it is estimated that the installation effects savings in conventional energy of some 50% per annum.

The Philips house in Aachen, W. Germany, is another well-known and serious project. It is more experimental in the equipment it contains and is operated through a load cycle by a computer.



SOLAR HEATING AND COOLING WITH THERMAL STORAGE

FIGURE 2

Work is also going on in other countries, for example

- Dornier House - one of a number of German projects
- Zero Energy House, Denmark
- Euroc House, Sweden

The EEC is also engaged in solar energy via a programme which is just getting underway, to investigate a number of the applications referred to earlier. The most notable of these is the 1 Megawatt solar power installation currently under definition by Ansaldo in Italy, MBB in Germany Electricité de France, and co-ordinated for EEC by General Technology Systems in the UK. The plant is scheduled to enter into its experimental operating phase in 1980. Ansaldo has built a demonstration solar driven steam generating plant in Genoa and this know-how is being incorporated into the EEC programme.

Of necessity it is possible only to touch upon the main programmes in the short space available in this paper but this does give an indication of the manner in which solar energy is receiving serious attention and is not thought of, quite so much, as a "crank" activity.

5. FACTORS INFLUENCING LARGE-SCALE EXPLOITATION OF SOLAR ENERGY

One might be forgiven for asking why, if solar energy is so attractive, is the world not rushing to hail it as its saviour from energy famine.

The reasons are many, somewhat complex and what is worse involve predictions of future conditions before conclusions can be drawn.

The nature of solar energy is such that the flux incident on a country is many times the energy consumption of its inhabitants but unfortunately energy density is low and intermittent. The collection of the energy is thus likely to be expensive in relation to other energy forms in use. The major obstacles in the way of its exploitation are therefore;

(i) the current relatively low prices of conventional fuels

(ii) the need to improve technical performance (in its widest sense) of solar equipment, associated with a reduction in cost.

These will now be examined in conjunction with a number of subsidiary factors which affect the picture.

- Economics

  For any solar installation, the important parameters are

  - the cost of the system
  - the cost of fuel saved

By considering characteristics of buildings, insolation, general weather conditions, solar system design, solar system costs and fuel costs, it is possible to compute such outputs as

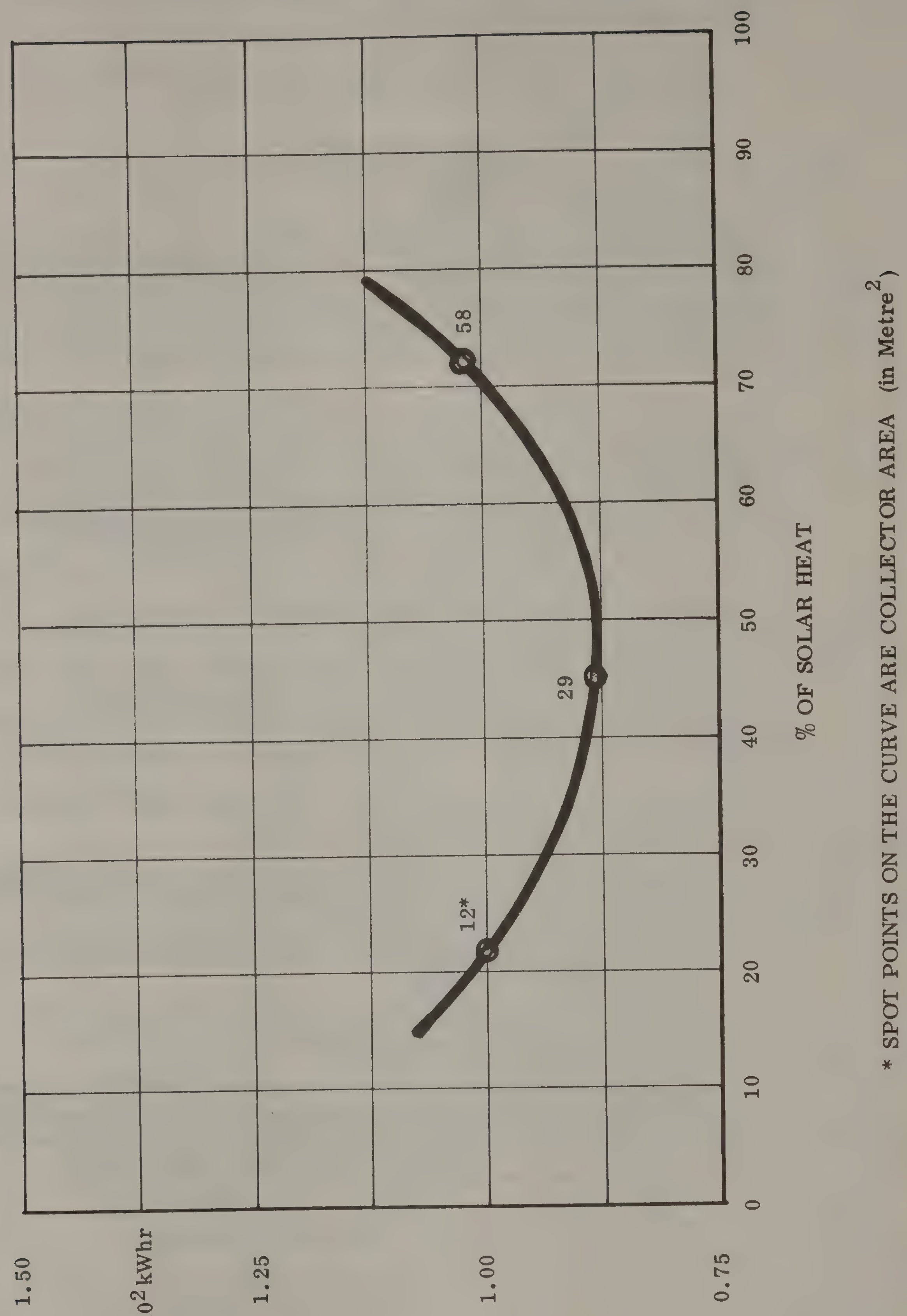
heating and cooling requirements
heating and cooling available from solar energy
solar fuel savings
Figure of Merit = $\dfrac{\text{Annual fuel savings}}{\text{total solar system costs}}$
system design optimisation

Figure 3 illustrates this optimisation of system size. For a solar system smaller than the optimum size, there will be very many days on which the solar energy available exceeds the capability of the system to collect and store it. Similarly, when the size is larger than optimum, the system is only able to take advantage of its (expensive) capacity on a few days.

At present, solar systems are not compared with conventional systems on the same basis. The use of solar energy requires that the consumer substitutes a capital investment for the usual, continuing purchase of conventional fuel or energy. Thus, the consumer's economics depend upon the comparison of the cost of carrying and amortising this investment with the savings in his continuing cost of conventional energy. This comparison between a consumer investment and the cost of producing and distributing a product (conventional energy) is an unusual one. The relationship between the consumer's economics on the one hand and national economics and the national interest on the other, is distorted in many ways. Thus the consumer tends to pay an average cost for energy, while the energy which he might save (from the national interest point of view) is the high cost final increment to the national supply.

In examining the economics of a solar installation several important factors have to be taken into account as follows

- in paying back capital and interest via a first or second mortgage, income tax allowance reduces the nominal 12-13% to more nearly 8%
- because of the effects of inflation, loan repayments are made in increasingly "soft" pounds
- because of the effects of scarcity, political actions, etc., fuel prices are expected to rise in real terms
- the solar installation, just as is the case for a conventional system, has a finite life. It must be maintained and, in the fullness of time, replaced. The operational life must, of course, exceed the time taken to recoup the initial investment and operating costs.



COST OF CONVENTIONAL HEAT vs PERCENTAGE OF SOLAR HEAT (Example)

FIGURE 3

An example will illustrate some of these points. The solar system performance parameters are taken from a published design.

Assume cost of solar installation	=	£1,000
Solar energy collected per annum	=	3856 kWh
Value of electrical energy saved	=	3856 x 0.0193
	=	£74.42/year
Net value saved (£74.42 - £10 to operate pump)	=	£64.42/year

This represents a 16 year payback period.

If we assume the £1,000 is paid back over a nine year period via a $12\frac{1}{2}$% mortgage and taking into account interest payments and tax relief, the following table lists the payments.

Repayment Year	Repaid Principal/Year	Interest/Year	Tax Relief/Year	Nett/Year
1	55.62	125.00	43.75	136.87
2	62.64	118.17	41.36	139.45
3	70.39	110.22	38.58	142.03
4	79.19	101.42	35.50	145.11
5	89.09	91.52	32.03	148.58
6	100.23	80.38	28.13	152.48
7	112.75	67.86	23.75	156.86
8	126.85	53.76	18.82	161.79
9	142.70	37.90	13.27	167.34
10	160.54	20.07	7.02	173.59
			Total	1524.10

The figures in this table ignore inflation and increases in fuel prices. The following table shows the effect of inflation rates of 5% and 10% and a fuel price rise of 5% in real terms.

Repayment Year	Nett/ Year	Nett/Yr in 1976 Prices		Fuel Saving (5% in Real Terms)	Put in Building Soc'y to give, at end, in 1976 prices	
		5%	10%		5%	10%
1	136.87	136.87	136.87	64.42		
2	139.45	132.81	126.77	67.64		
3	142.03	128.83	117.38	71.02		
4	145.11	125.35	109.02	74.57		
5	148.58	122.24	101.48	78.30		
6	152.48	119.47	94.68	82.22		
7	156.86	117.05	88.54	86.33		
8	161.79	114.98	83.02	90.65		
9	167.34	113.26	78.07	95.18		
10	173.59	111.90	73.62	99.94		
	1524.10	1222.76	1009.45	810.27	894.34	738.98

This shows that after six years the savings in fuel exceed the annual repayments (in 1976 prices). The pay back period has now dropped to 10-11 years depending on inflation rate.

It is interesting to repeat the calculation for the case of the individual who has £1,000 to spend on a solar system, and to compare the return with that from investment in, for example, a Building Society at 7¼% tax paid. The following table shows the compounded returns on the Building Society investment, expressed in 1976 prices at 5% and 10% inflation, and compared with the fuel savings from the previous table.

Repayment Year	Compounded Investment	Expressed in 1976 Prices at 5% inflation	Expressed in 1976 Prices at 10% inflation	Fuel Saving 5% in Real Terms	Put Fuel Savings in Building Soc'y to give end returns shown in 1976 prices 5% inflation	Put Fuel Savings in Building Soc'y to give end returns shown in 1976 prices 10% inflation
1	1000			64.42		
2	1072.50			67.64		
3	1150.26			71.02		
4	1233.65			74.57		
5	1323.09			78.30		
6	1419.01			82.22		
7	1521.89			86.33		
8	1632.23			90.65		
9	1750.57			95.18		
10	1877.48	1210.24	796.23	99.94		
				810.27	894.34	738.98

Thus, at the end of the period, the investor in the building society has a sum with the purchasing power at todays prices of £1,210 or £796 depending whether inflation is 5% or 10%.

The solar system installor has a sum of £894 or £738 again depending on inflation rate, and is also the owner of a valuable system earning £100 per year and more, at todays prices. In addition he is helping to conserve fast-diminishing and expensive fossil fuels.
This calculation shows how close to financial viability is even current solar technology.

Technical/Cost Factors

The above calculations illustrate the enormous effect on system economics which would result from cost reductions or, conversely improved performance for a given cost. Some of these reductions will come from large-scale production; some from better conversion or collection efficiency, reductions in size, easier installation, etc.

In the case of solar cells, costs have to be reduced by at least two orders of magnitude if more widespread use is to be achieved - though cells are used today in many remote applications where no other practical means exists of providing energy.

Air conditioning is an application which is also some way from economic viability owing to the lack of suitable hardware at present. The low COP of heat actuated machinery, compared to electrically actuated machinery, causes solar heat value to be low at this time. Against this is the fact that cooling is most needed when solar flux is at its strongest, as shown in Figure 4 which illustrates flux versus demand for an experimental solar heating and air-conditioning system in Italy.

- Installation Factors

  It is not just the collector which is important, but the whole system as we have seen earlier. Solar energy will never be a serious contributer to the overall scene until all these features are catered for (see Figure 5). How many collectors are marketed which pay no attention to method of mounting, performance of other system elements, etc.?

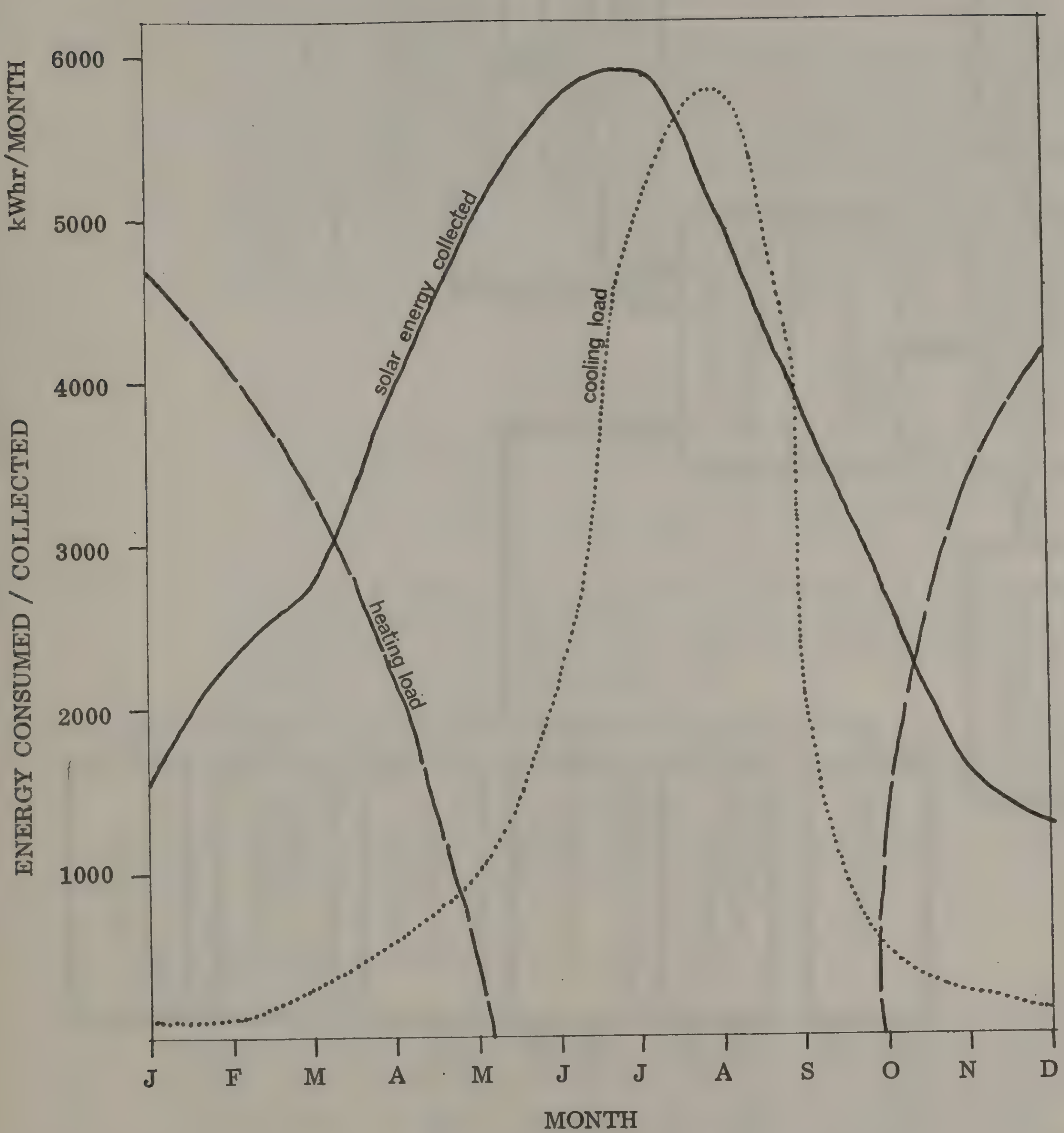
  Reference has also been made to the need for the right environment to be generated in which solar energy can develop. Codes and practices need to be defined, architects and systems engineers made aware of design methods and capabilities, planning authorities need to take account of the orientation and shape of buildings in increasing the applicability of solar energy.

  Solar energy lacks an initiator at present in the sense of bodies which can take the lead in designing total systems - building and solar system, etc.

  More evidence must be amassed of the lifetime and long-term reliability (corrosion, leakage, etc.) of solar systems before authorities will feel confident of "pushing" them. The views of insurance companies are important in this context. These aspects are arguably more important than pursuing more research programmes - solar energy will not make its market breakthrough without this proving phase.

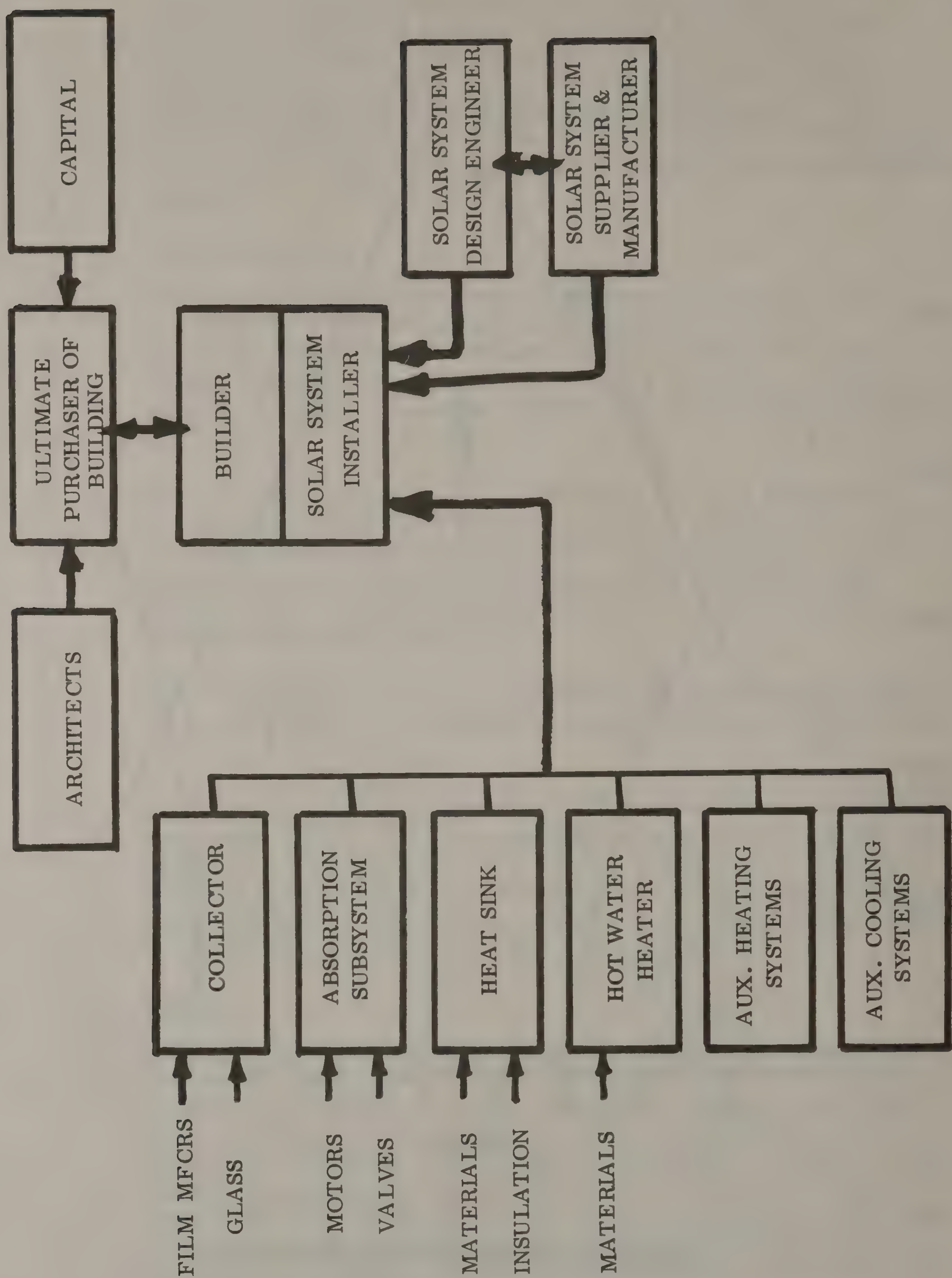
- Politics

  One must not underestimate the impact of politics on the development of this energy form. The UK Government is heavily involved in the exploitation of North Sea oil and gas, decisions on nuclear power policy, labour relations in the coal industry, power station fuelling policy, energy prices within the overall fight against inflation, and more. In addition there appears to be uncertainty about the relative merits of alternative energy forms such as solar energy, wave power, wind power, geothermal energy, and the like. As a result one looks in vain at present for a strong solar energy policy within the UK; there is a less than leading role within the EEC programme; and no strong policy towards Third World markets.



ESTIMATED ENERGY DEMAND AND SOLAR
ENERGY COLLECTED THROUGHOUT THE YEAR

FIGURE 4



CUSTOMER-SUPPLIER RELATIONSHIPS FIGURE 5

In addition, the odd rule that new projects must give a return on capital invested of 10% per annum, after allowance for money inflation, is an effective block on long term investment.

- Market Potential

The potential market size for solar installations, even of the relatively conventional space and water heating type, is a further area of contention. It is interesting to compare the various approaches to the projection of market growth and structure; many are based on a minimal amount of information and method whilst at the other end of the spectrum is a million-dollar study carried out on behalf and with the participation of some 90 US, European and Japanese companies in 1974/75. This foresaw global markets of domestic, commercial and industrial solar heating and air-conditioning equipment as follows;

	Conservative Outlook	Optimistic Outlook
Per year by 1980	\$170 million	\$600 million
Per year by 1985	\$420 million	\$1300 million

To put the economic calculations above into context, the study foresaw later generation higher performance collectors at \$75 per sq. metre installed whereas the example in this paper used £40 per sq. metre (\$70/sq.m) for current technology.

In the UK the statement is usually made that solar energy is not suitable for our climate. The Milton Keynes house saves some 50% of conventional energy costs which looks interesting. However, solar energy is believed by many to promise large markets in developing countries - a factor which other European countries have not been slow to notice.

6. LONG TERM POTENTIAL

Space engineers are at present seriously studying an application of solar energy which at first sight looks like pure science fiction. This is the conversion, in geostationary orbit, (the orbit in which a satellite or space station circles the earth at the same rate at which it rotates and hence remains always above the same point on the equator), of energy from the sun into microwave radiation which is then beamed to collectors on the earth's surface. This extremely high frequency radiation is converted back into electricity which is then distributed via a grid network.

The satellite power station is built up from a large number of modules launched into near earth orbit by re-useable launchers such as later generations of the Shuttle. There they are assembled into larger elements which can then be transferred into geostationary orbit (22,000 miles above the earth) for final assembly into a complete power station.

In one design, a huge array of solar cells is maintained pointing at the sun. The electricity from this is converted into microwaves suitable for electromagnetic transmission (like radio waves) to Earth.

Another design utilises a giant array of mirrors which concentrate the sun's radiation onto a thermal engine where a working fluid - eg helium - is heated and used to drive turbines which in turn drive electrical generators.

Space is also being considered as a site for factories in which processes and products which cannot be achieved on Earth will be developed. This may also be the answer for the safe siting and operation of nuclear power stations. Waste products can easily be fired by rocket into the sun, and the weightless environment may prove to be ideal for the containment of the plasma in fusion plants.

7. CONCLUSIONS

This paper has attempted to highlight the factors having an influence on the exploitation of solar energy as a significant contributor to the world's armoury of energy sources; to demonstrate the wide range of applications and the potential of solar energy as a large-scale energy provider, as well as the better known small-scale uses; and the need for early and determined programmes of demonstration and development so as to ensure that maximum savings of non-renewable resources may be made using equipment which is economically competitive with conventional fuels.

43rd ANNUAL CONFERENCE

EDINBURGH

11th - 15th October, 1976

The Utilisation of Solar Energy

by

Bernard McNelis
General Technology Systems Ltd
formerly of
Solar Energy Developments

National Society for Clean Air,
136 North Street,
Brighton BN1 1RG.

INTRODUCTION

The Earth's supply of fossil fuels is finite. There are many arguments about the exact date by which the supply will be totally depleted, but this date is within the forseeable future. Nuclear fission could supply our needs, but there are technical and also serious environmental problems. Nuclear fusion is very attractive as an energy supply but it is as yet an unproven technology. It is therefore essential that steps are taken to expand research, and development in the field of, so called, 'unconventional' energy sources, and also create an appropriate environment in which applications can expand. Of these energy sources, solar, as the primary and most abundant supply of energy, offers immediate utilisation in low temperature applications, and potential economic application in very large scale power production.

ENERGY CONSUMPTION AND THE AVAILABILITY OF SOLAR ENERGY

The consumption of energy by individual countries such as the UK, and by the Earth as a whole has been quantified elsewhere, and trends of world energy consumption have been assessed and predicted by, for example, the Institute of Fuel.[1] The relationship between energy consumption and solar energy availability has been indicated by many authors in different ways, and repeating some of these, so as to give perspective to the immense amount of primary energy which could be exploited, it can be stated that the present world energy consumption is less than the solar energy intercepted by a region 100 km square in a favourable location. Considering the UK, a conversion device with an efficiency of 10% would require 7.8% of the UK land area to supply all our energy demand (1973 level) while to supply only our electricity demand from the same device would require 0.96% of the land area.[2] In comparing the availability of solar energy with the world's known fossil fuel reserves, one can conclude that the total fossil fuel supply has a chemical energy content equivalent to the solar energy intercepted by the earth in less than two weeks.

Outside the Earth's atmosphere the solar energy flux is almost constant at about 1.35 kW m^{-2}, but absorption and scattering processes in the atmosphere reduce this flux to a maximum of about 1.0 kW m^{-2} at sea level. The processes occuring in the atmosphere and at the surface of the Earth due to the incoming solar radiation, and the net energy balance are indicated in fig. 1. The total solar energy available in a year at a given location depends on a latitude and local climatic conditions. Solar intensity is diminished at high latitudes because of the longer path through the atmosphere and hence more absorption and scattering, and at higher latitudes there is a pronounced variation between summer and winter energy availability.

Solar energy input (horizontal surface) to the inhabited part of the earth varies from about 700 kWh m^{-2} year $^{-1}$ in some parts of Northern Europe to about 2300 kWh m^{-2} year $^{-1}$ in some desert regions of the USA. The average for southern England is about 890 kWh m^{-2} year $^{-1}$ and this varies during the year from about 0.4 kWh m^{-2} day $^{-1}$ in December to 4.5 kWh m^{-2} day $^{-1}$ in June. This seasonal variation, and also the fact that there can be many consecutive days where there is virtually no insolation, are possibly the greatest problems to successful exploitation of the solar resource rather than the net annual energy available.

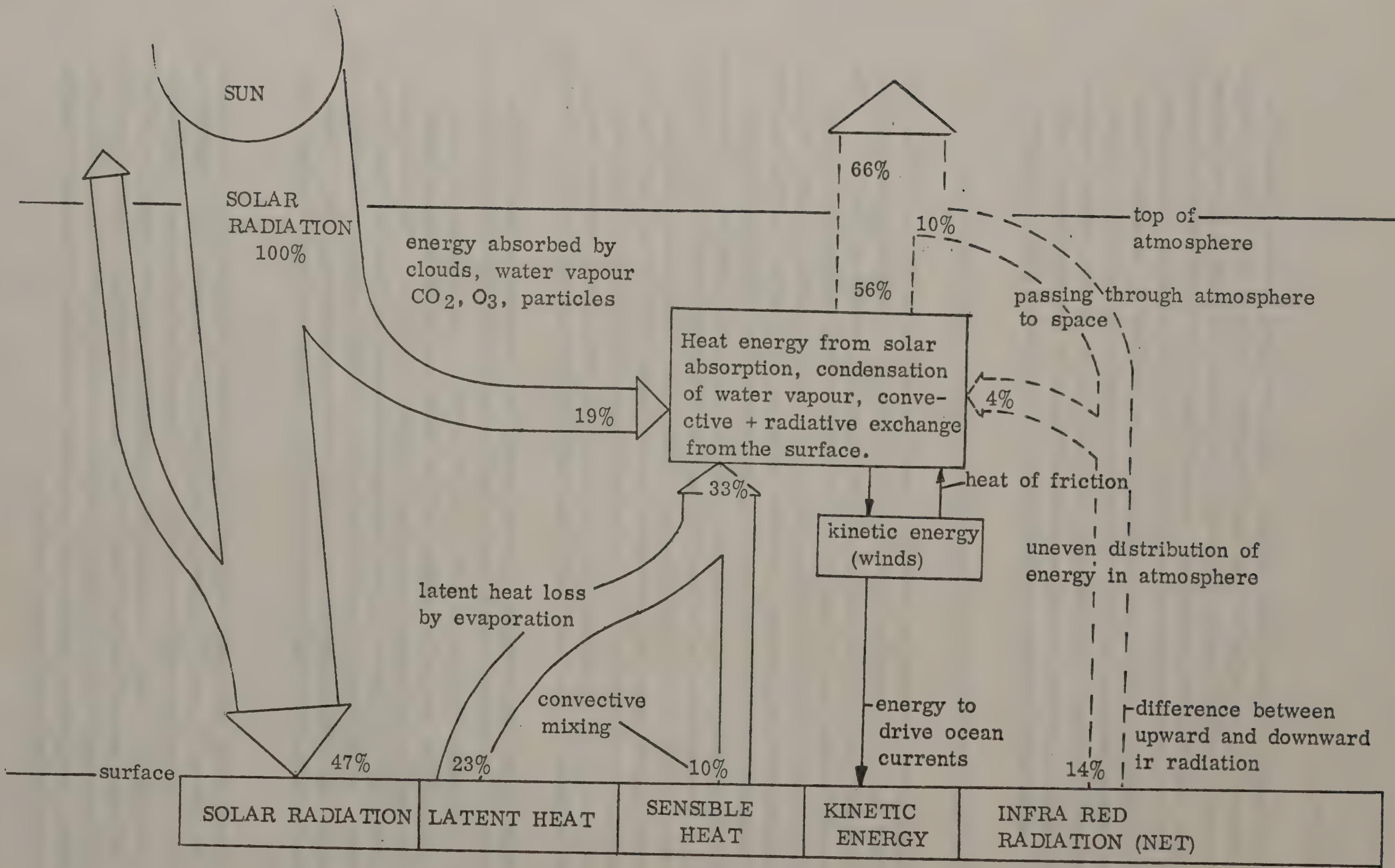


Fig 1 Energy Exchange of the Earth and Atmosphere (Adapted from Pearman[3])

COLLECTION AND CONVERSION OF SOLAR ENERGY

The solar energy which reaches the Earth's surface is partly reflected and partly absorbed causing a heating effect on the surface which in turn gives rise to longer wavelength re-radiation. This is in effect a constant energy flow and fixes the equilibrium temperature of the Earth. Some of this energy flow can be tapped and re-routed so as to do work before being dissipated as heat and re-radiated to space. An indication of the range of ways in which solar energy can be converted to more useable energy forms, such as fuel, electricity, and heat is given in figure 1.

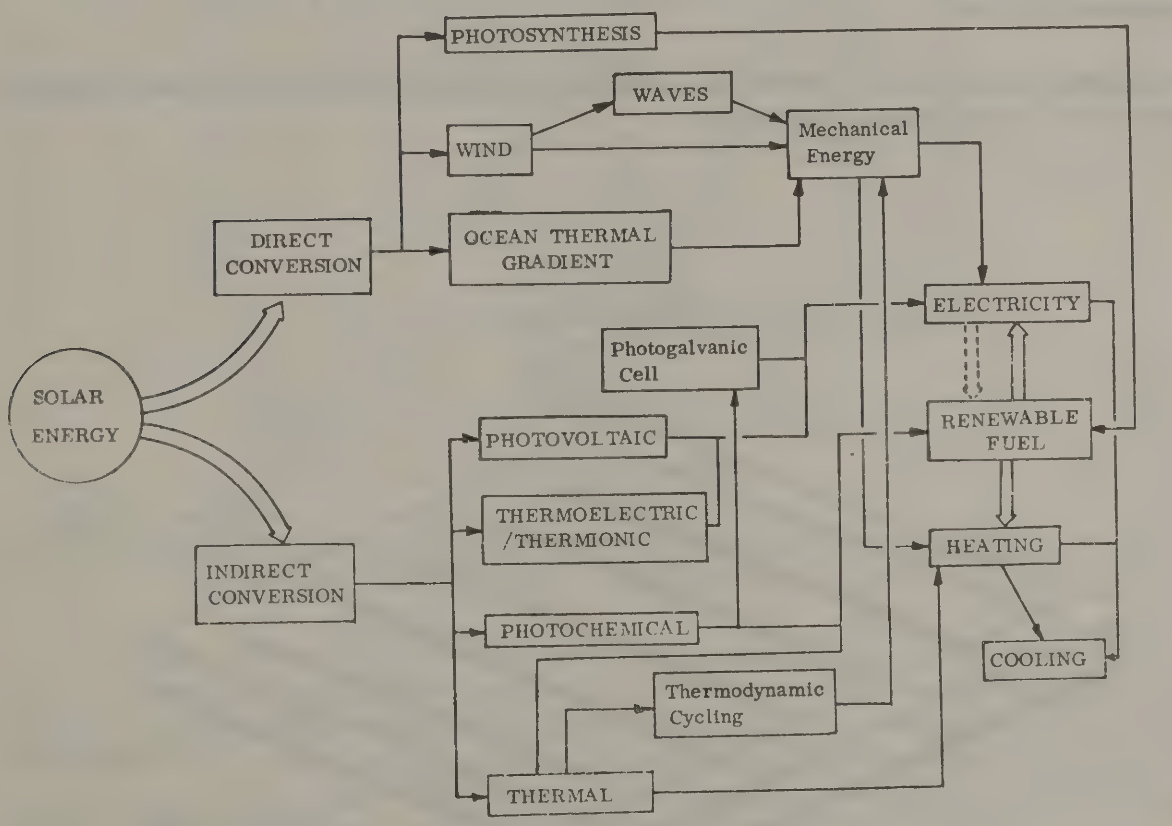


Fig. 2 Alternative Conversion Paths for Solar Energy

Solar energy is already collected and stored on a vast scale by photosynthesis, yet only about 0.02% of the incoming solar radiation is fixed in this way. There is considerable scope for greater energy production through photosynthesis(4) and the production of biomass for fuel is currently being studied in Ireland (5). Photochemical conversion also offers promise both as a means of producing electricity via a photogalvanic cell (regenerative fuel cell) or by direct conversion to storeable fuel (6). It is not possible to deal with these aspects in further detail here.

The Photovoltaic Cell

This is a device which converts sunlight directly to electricity. Solar cells have been used extensively in spacecraft, and have been developed into extremely practical and reliable devices. [7]

A photovoltaic cell is effectively a large area semiconductor diode constructed so that incident light can penetrate into the region of the diode p-n junction. A semiconductor material will absorb radiant energy where it generates excess holes and electrons (one electron-hole pair for each photon of light). If this occurs near the p-n interface the electric field present will act to separate the holes from the electrons causing a buildup of holes in the p-type material and electrons in the n-type region. These excess charges can be made to flow through an external circuit to provide power to an external load.

The silicon cell is the best developed, and the construction of the type used for space applications is indicated in figure 3.

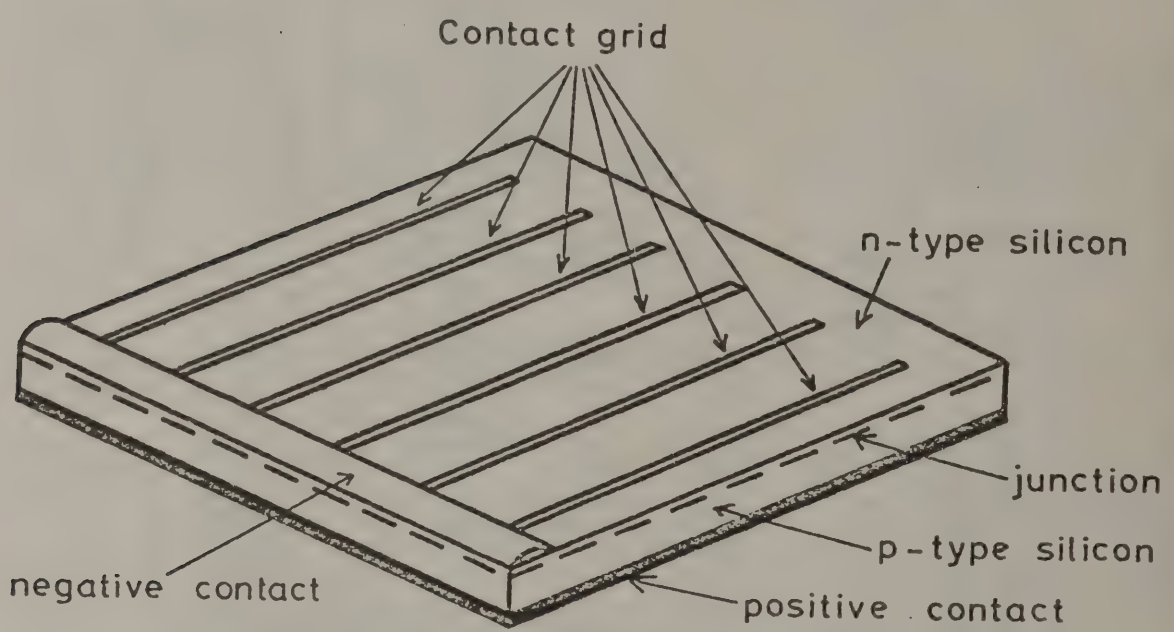


FIG.3 Silicon Solar Cell (Reproduced with permission from ISES-UK)

A silicon cell develops a potential of about 0.45V, which is a characteristic of silicon and is independent of cell size, while current output is directly propotional to area and incident solar intensity. The efficiency of a silicon cell is typically about 10%, while 16% has been achieved (the theoretical maximum is 24%). Solar modules for terrestrial use are manufactured in the UK by Ferranti, and US products are marketed by Lucas and Solarpak Products.

The best known module is the Solar Power Corporation 1002 (marketed by Lucas). This employs five 55mm diameter circular cells mounted on a printed circuit board and encapsulated in a polycarbonate case with silicone rubber. Power and current versus voltage curves for this module are given in figure 4.

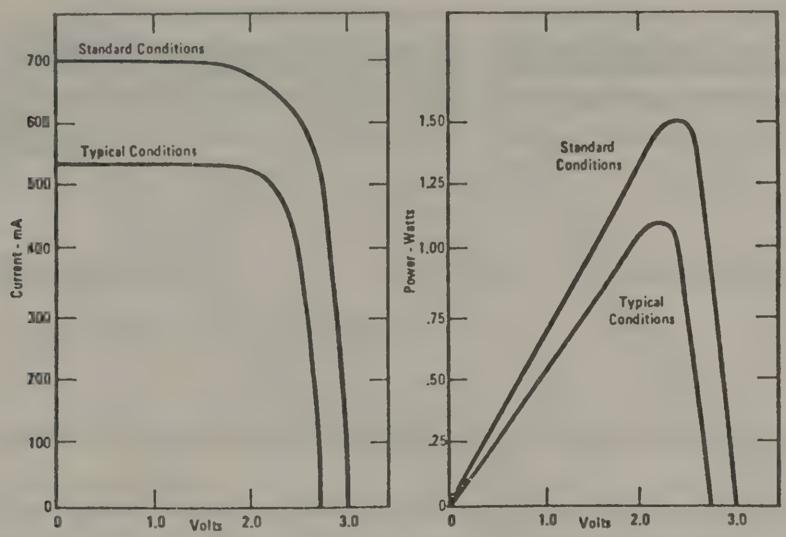


FIG. 4 Electrical Characteristics of the SPC 1002 Photovoltaic Module. (Reproduced with permission of Solar Power Limited)

Standard conditions are 1 kWm^{-2} insolation, $0^{o}C$ cell temperature, sea level, and typical conditions are 800 Wm^{-2}, $25^{o}C$ ambient temperature and again sea level.

All of these modules cost about \$20 $W(peak)^{-1}$. At this price level the only market is in places without mains electricity supply, but this can be a considerable size, for example, in developing countries [8]. Installations in the UK include three radio repeater stations in Scotland, two operated by the Civil Aviation Authority, and one by the Forestry Commission, two lighthouses in the South of England, a railway signal system operated by British Rail, together with many more trial systems.

An alternative to the use of silicon is the thin film approach. The best known example is the cadmium sulphide cuprous sulphide cell, and this is indicated in figure 5.

Cadmium sulphide cells could be potentially much cheaper than silicon cells as the extensive purification to produce semiconductor grade material is unnecessary and the material films can be evaporated on in a manner which is already a well established technology. International Research & Development (IRD) demonstrated devices some years ago, but currently cells are not commercially available in the UK, but a company Solar Energy Systems Inc. (SES) which is owned by Shell, is trial marketing terrestrial modules in the USA.

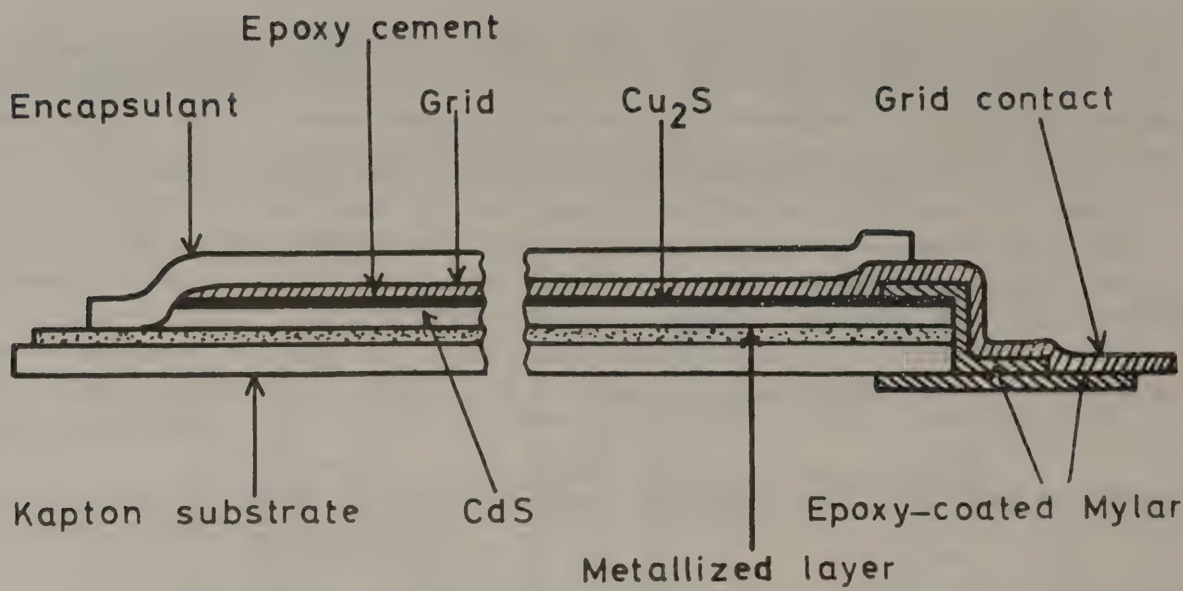


FIG. 5 CdS-Cu_2S Solar Cell (Reproduced with permission of ISES-UK)

Major R & D efforts are underway to reduce costs of solar cells and the US programme has as one of its milestones, the development of cells costing \$0.40 W(peak)$^{-1}$ by 1985 [9] and cost predictions have been further evaluated in detail [10]. In the UK work is underway on development of ribbon silicon for solar cells at Metals Research, and also on cadmium sulphide - cuprous sulphide thin film cells at International Research and Development (IRD), G.V. Plannar, and PATS Centre, the latter having developed prototype cells which could be marketed at \$0.20 W(peak)$^{-1}$ if mass produced [11].

Plessey have been working on gallium arsenide semiconductor cells for some time and recently Standard Telecommunication Laboratories have announced a system [12] in which a Fresnel lens concentrates sunlight onto a GaAs cell and a novel sun tracking device is used to maintain the solar image on the cell.

Generation of electricity by photovoltaic conversion on a large scale is being studied in depth [13] but because of the relatively low efficiencies, and hence large area requirements, centralised systems, rather than individual houses producing electricity for their own consumption, are favoured.

Solar Heating

Of the total primary energy consumption in the UK about 50% is used in buildings, 29% being in domestic buildings [14]. Approximately 64% of the mean net energy consumption of a household is used for space heating, and about 22% for water heating, and so there is considerable scope for the use of solar conversion devices in this sector.

The flat plate solar collector which converts solar radiation to thermal energy has been extensively developed. The construction of a typical collector is indicated in figure 6.

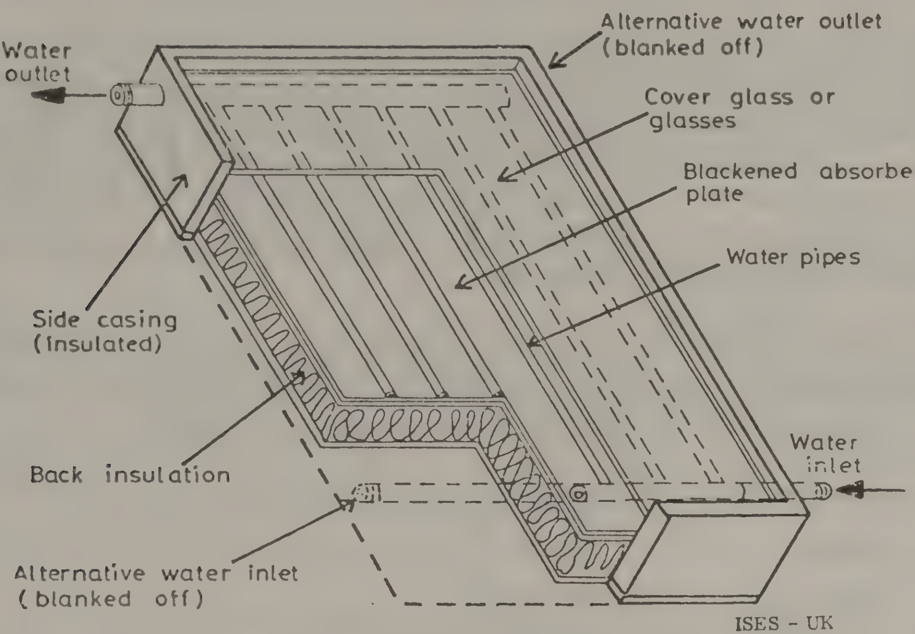


FIG. 6 The Flat Plate Solar Collector (Reproduced with permission of ISES-UK)

When radiation falls on the matt black surface typically between 80% and 98% is absorbed (the amount depending on surface characteristics) the remaining 20% or 2% being reflected. This absorption is a complex process but the net effect is that the radiant energy is degraded to heat. Some of the heat is transferred to other parts of the body by conduction and some is lost to the environment by convection and radiation. The total heat loss depends on the temperature difference between the surface and the environment, and so increases as absorber temperature increases. When the heat loss rate is equal to the radiation input an equilibrium temperature is reached. If the surface of the absorber plate is covered with transparent material, such as a sheet of glass, the heat loss is greatly reduced without much reduction in the energy input. This is due to a reduction in corrective losses, from the plate, and also because of the selective transmission of the glass; visible light can pass through to the absorber, but infra red (heat) radiation emitted by the plate cannot travel outward.

If a fluid is circulated in thermal contact with the absorber plate it will be heated, and some of the heat absorbed by the plate will be removed and may be transferred to other energy conversion or storage sub-systems.

In the UK, because of the seasonal and daily variation in the solar energy available, solar heating devices must be considered as devices for fuel economy rather than replacements for conventional systems. This is because of the lack of availability of any viable form of long term thermal storage. Interseasonal storage systems are the subject of a number of studies, which are mentioned later.

Flat plate collectors have been used in the UK for heating swimming pools for many years where economics are very favourable [15]. More recently their use for provision of domestic hot water has increased immensely and the number of UK manufacturing and marketing organisations providing flat plate collectors is continuously growing. A recent survey [16] compared 28 collectors from 20 companies, and suggested that there was a total of about 30 suppliers, and more recently the author has compiled a list of 78 such companies.

The survey indicated that collector prices varied from £10m^{-2} for an aluminium roll bond absorber plate to £100m^{-2} for a collector complete with frame, insulation and glazing. Average prices for different collector materials were:

Aluminium	£52 m^{-2}
Copper	£51 m^{-2}
Steel	£48 m^{-2}
Plastic	£27 m^{-2}

and recently a DIY kit including 2 panels (steel on aluminium, total area 3.8m^2) with acrylic sheet glazing, circulating pump, differential temperature controller and a gallon of antifreeze for £225 [17] has become available.

Local Authorities have become interested in provision of solar water heating systems in their houses, and the South London Consortium [18,19] will be providing a 5m^2 array on a house and are experimenting with a 1m^2 test rig while Telford Development Corporation [20] are assessing the performance of two systems; a 4.1m^2 aluminium collector located on the porch of a house and operating on the thermosyphon principle and a 4.7m^2 mild steel collector mounted on the roof of the same house.

Patterns of domestic energy use can vary widely and so the optimum size for a solar water heating installation also varies. ISES-UK [21], consider 4m^2 suitable for an average household and suggest this would operate at an average efficiency of about 35% over the year, supplying 30 to 40% of heat required for water heating. The Building Research Establishment (BRE) [22] have calculated that this size of collector would provide about 40% of heat required or perhaps 50% in South West England. Brinkworth [23] considers that 15m^2 would be necessary to provide most of the hot water requirements in summer and a useful fraction of it in winter.

The use of flat plate collectors for space heating has been studied in the UK, but there is considerably less activity than with water heating. Whereas domestic hot water is required all year round and so a collector installation can be effectively utilised through the summer, space heating is not usually necessary at this time, and in fact reaches a peak when solar energy availability is at a minimum. This means that a collector must be sized for winter heating and be only partially utilised during summer, or some form of interseasonal energy storage must be provided. Additionally, because collector efficiency is reduced considerably with increase in temperature it is not sensible to connect flat plate collectors to a conventional heating system using hot water radiators.

Solar space heating (together with water heating) is being examined in a house at Milton Keynes [24] where $40m^2$ of aluminium roll-bond collectors are used with $5m^3$ of water for thermal storage (about 1 winter's day heating capacity) and heat is distributed using a water-to-air heater battery. The BRE [25] are currently building a house which will employ $22m^2$ of collector and $35m^3$ of water for (interseasonal) thermal storage. These two examples indicate the trade-offs which can be made between collector area and thermal storage capacity. More recently the UK's first speculatively built house with space heating has been completed [26], and this uses a system similar to the Milton Keynes house.

Present R & D is aimed at improving collector and complete system efficiency and reducing costs. Additionally, some standardised approach to testing and performance rating of collectors is necessary. The National Bureau of Standards in the USA [27] has carried out some pioneering work and currently in the UK ISES is collaborating with British Standards [28] to reach some performance standard. The EEC Joint Research Centre at Ispra (Italy) is assessing the performance of identical collectors in different parts of Europe and in the UK the Solar Energy Unit at Cardiff and the BRE are collaborating.

Relevant activities in Europe and other parts of the world have been reviewed by ISES [2] and in a contract for the EEC [29].

The Economics of Solar Heating

A solar hot water system with $4m^2$ of collector could be expected to save about 1500 kWh $year^{-1}$ [21,22]. Obviously the amount of money saved depends on the fuel which is offset, but with electricity at £0.02 kWh^{-1} savings would be £30. The cost of this system would vary between about £300 using commercial collectors installed by the owner to about £600 to £700 if professionally installed, while the Telford Development Corporation simple system [20] is claimed to cost only about £150. Obviously looking at these figures the economics do not appear favourable as was concluded by Courtney [22], who using £300 as the cost of a system and electricity price of £0.019 kWh^{-1} concluded that an annual increase in real energy

costs of 7% would be necessary to make the collector cost effective. In another study reported at this conference Brunt (30) has studied the economics of solar heating systems using figures published by ISES-UK (2) and when considering the effect of inflation on the value of capital has concluded that this current solar technology is very close to financial viability.

Some of the UK manufacturers of flat plate collectors suggest that economics are very favourable and in fact companies have been known to quote savings which are at least misleading (31). Some manufacturers also quote that their systems will pay for themselves in 4 (32) or less than 5 years (33) and the latter suggests that the purchaser can pay for his system over 5 years, his monthly payments being more than offset by savings on his average monthly fuel bills.

Solar Thermal Power

Flat plate collectors can be used to drive heat engines and hence generate electricity, and a 10 kW(peak) system is currently being tested in Munich (34) before being installed in Almaria (Spain), and flat plate collectors have been used to drive engines for water pumping for some time (35). However, the low operating temperatures and the second law of thermodynamics means that efficiencies are not very high.

In order to increase efficiency, operating temperatures must be increased and this involves focussing solar energy onto an absorber which requires that the sun is tracked. A large proportion of the UK's insolation is diffuse and therefore cannot be focussed, and so it does not appear possible that such systems will find application here. However, these systems have been considered in this country (36) and studied in depth in the USA (37) where cost estimates of \$1000 kW (installed)$^{-1}$, which is very competitive with conventional systems, have been prepared. The UK is participating in two international collaborative efforts to develop large scale solar-electric generating plant.

The EEC has supported a study of the technical feasibility and system definition of a 1 MW(el) helioelectric power plant, and is currently considering its construction as a demonstration and experimental facility. This is based on the heliostat field/central receiver concept in which a large number of identical (nominally flat) mirror systems (or heliostats) track the sun and continually reflect the incident energy into a receiver placed at the top of a tower. Super-heated steam is generated in the receiver and this drives a conventional turbine coupled to an alternator. This work has been conducted by a team drawn from Germany, France, Italy and the UK (38). The concept is summarised in figure 7.

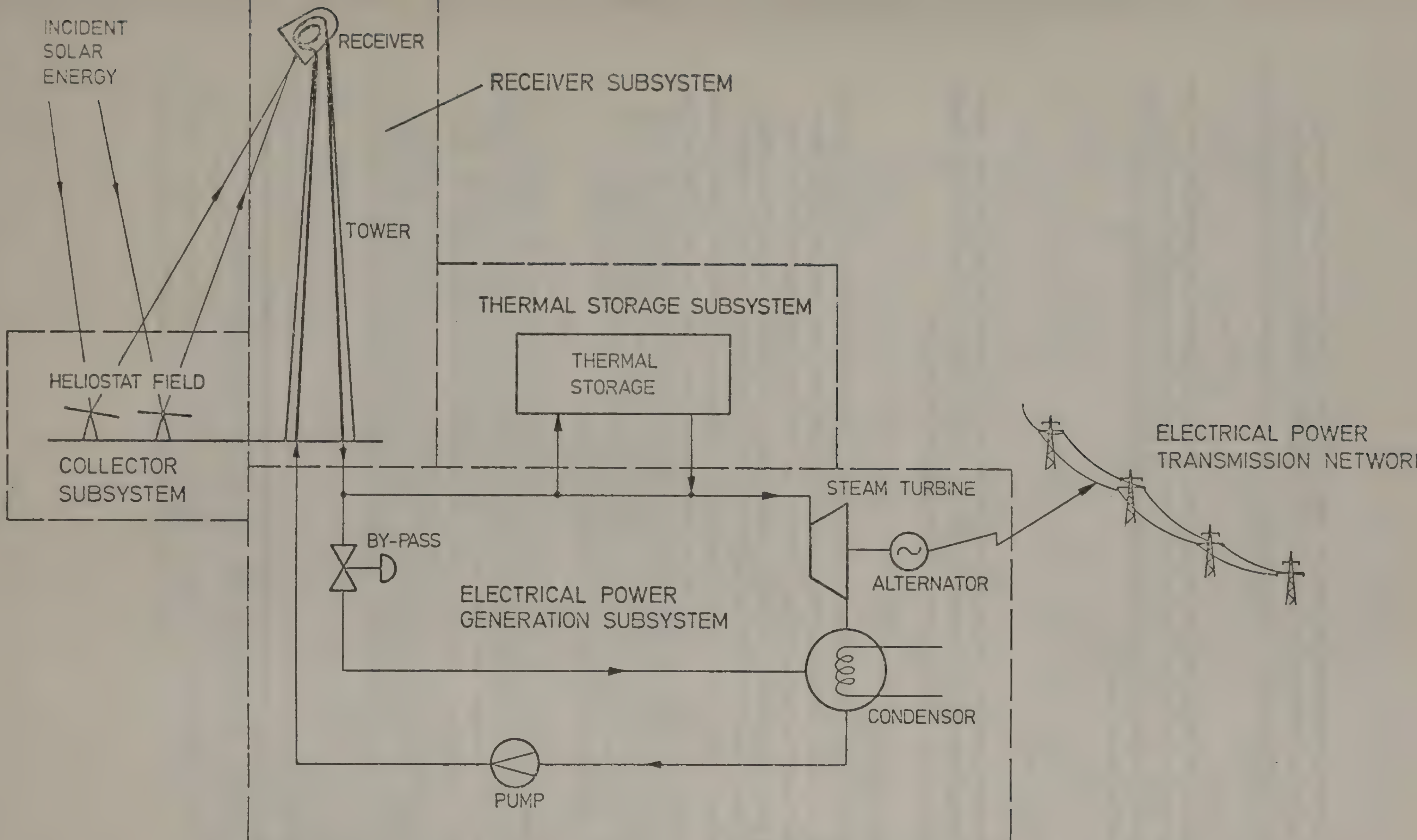


FIG. 7 Central Receiver/Heliostat Field Solar Power Generation Concept

A second power generation project has been initiated by the International Energy Agency under the leadership of Austria [39] to build a 500 kW(el) plant probably using distributed parabolic trough collectors and a conventional steam cycle/electrical system.

The economics of large scale solar thermal electricity generation systems have been examined in the USA where they are believed to be favourable and in Europe the International Institute for Applied Systems Analysis are studying these systems [40] as options for energy supply.

ENERGY STORAGE

The intermittent nature of solar energy means that for almost all applications some form of energy storage is necessary, both to act as a 'buffer' for satisfactory system performance and to allow operation in the absence of sunlight.

Photovoltaic Systems

Photovoltaic power systems employ conventional electrochemical batteries, such as lead-acid or nickel-cadmium, which power the load, and are charged by the solar cells when insolation is available. There is no back up power supply (other than battery capacity which may be much greater than is necessary) and so the energy storage system operates interseasonally. With an application such as a navigation light, the solar cell array charges the battery during the day, and the battery powers the light during the night. Thus the battery experiences a shallow daily charge/discharge cycle, but this is superimposed on a deeper yearly cycle because the daily load is greatest when the solar input is least and vice versa. The variation in the battery state of charge throughout the year in relation to the insolation input for a simple, energy matched case, is indicated in figure 8.

It can be seen that state of charge is out of phase with energy input by minus $\frac{1}{4}$ year. This shows that at the autumn equinox the solar input is matched to the load, and the battery is fully charged, and there after the battery slowly discharges as there is insufficient insolation to meet the load. At the spring equinox the battery is (theoretically) completely discharged but the solar input is again sufficient to meet the power demand on the system and then to power the load and also charge the battery. In practice the battery capacity is always such that it is never less than about 20 or 30% of its rated value.

Thermal Systems

Interseasonal energy storage as described above, is not generally applied in solar thermal systems, this being for both technical and economic reasons.

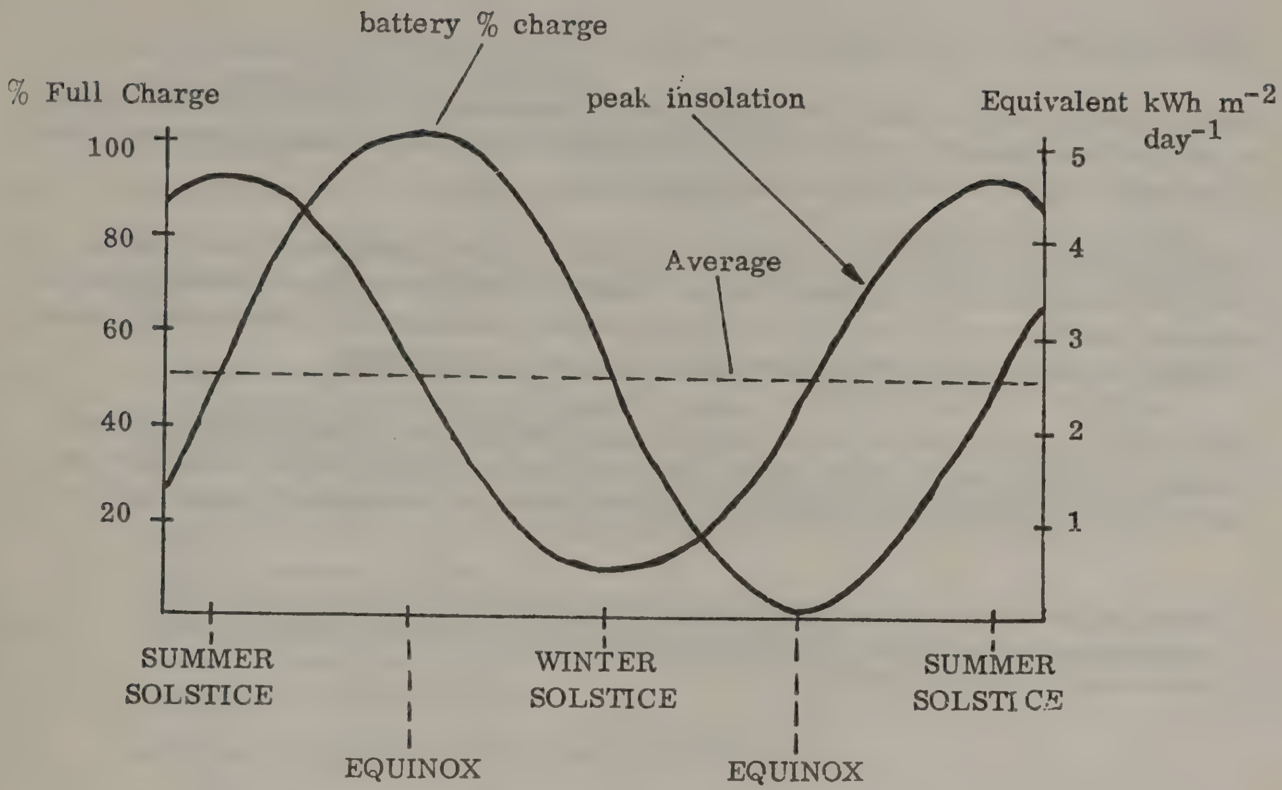


FIG. 8 Variation of battery state of charge throughout year (ideal system)

All the solar installations in the UK to date have employed the sensible heat of water for thermal energy storage, water having a very high thermal capacity (1.16 kWh m^{-3} $^{o}C^{-1}$) and being very cheap. The Milton Keynes house uses 5 m^3 of water with an effective capacity of about 90 kWh. An alternative storage medium, used in the USA in conjunction with air heaters, is crushed hocks which have a thermal capacity of about 0.4 kWh m^{-3} $^{o}C^{-1}$ or about $\frac{1}{3}$ that of water. With both these systems the volumes necessary for a year round storage system is considerable (especially when thermal losses, or 'self-discharge' of the system is considered) and although water and hocks are cheap, suitable containers are not.

An alternative is the use of the latent heat associated with a phase change of a material, which is many times greater than the sensible heat associated with the temperature differences in solar heating systems. Telkes has studied latent heat of crysallisation materials extensively [41] and the Solar 1 house at Delaware University uses a three stage system based on this approach. The main heat store uses sodium thiosulphate pentahydrate which loses its water of crystallisation at 49°C absorbing heat, and the complete unit is contained in 3.2 m^3 with a capacity of 235 kWh.

Even greater quantities are associated with chemical reactions and systems are currently being studied in the UK [42] which offer promise of an interseasonal thermal storage system which does not suffer from thermal losses.

CONCLUSIONS

Photovoltaic cells are being used economically throughout the world to produce small amounts of electricity. R & D in progress should reduce costs considerably and lead to an expansion of the market for these devices.

The flat plate solar collector is readily available in many different forms from an ever growing number of manufacturers. Depending on how one views future rates of inflation and fuel costs, hot water can be provided economically. Solar space heating is being employed in the UK but the economics are not yet clear.

Electricity can be generated on a large scale using high temperature solar thermal systems. Published American studies indicate that economics should be attractive, but European studies in progress will lead to a better appreciation of costs involved.

The major limitation to the utilisation of solar energy on a larger scale is its intermittent nature, and the consequent requirement for an efficient and cost-effective energy storage system.

REFERENCES

1. Anon. Energy for the Future, Report from working party authorised by the Council of the Institute of Fuel (1973).
2. Anon. Solar Energy - a UK Assessment, prepared by UK section of International Solar Energy Society. (The Wolfson report) (May 1976).
3. G.I.Pearman, Energy Conversion, in H.Messel & S.T.Butler, 'Solar Energy', Pergamon Press (1975)
4. D.O.Hall, Photobiological Energy Conversion, FEBS Letters 64 6 - 16 (1976).
5. E.Lalor, Fuel Crops, ISES-UK/Reading University Conference, Solar Energy in Agriculture, (September 1976).
6. M.D.Archer, Photochemical Aspects of Solar Energy Utilisation, Specialist Periodical Report on Photochemistry, Chemical Society (London) 739-764 (1975)
7. See for example : J.A.Merrigan, Sunlight to Electricity - Prospects for Solar Energy Conversion by Photovoltaics, MIT Press (1975).
8. C.Weiss & S.Pak, Developing Country Applications of Photovoltaic Cells, Nat. Solar Photovoltaic Program Review Meeting (ERDA) (January 1976).
9. R.H.Blieden, the ERDA Solar Electric Application Directorate - Objectives and Strategy, (November 1975).

10. R.M. Moore, Cost Predictions for Photovoltaic Energy Sources, Solar Energy 18 225 - 234 (1976).

11. J.Watt, Private Communication (August 1976).

12. D.H. Mash. STL Publicity Material (1976).

13. S.L. Leonard, Final Report : Mission Analysis of Photovoltaic Solar Energy Systems, Aerospace Corporation (USE) report ATR-76 (7476-01) (3 volumes) (December 1975).

14. P. Bakke et al (BRE Working Party). Energy Conservation - a study of energy consumption in buildings and possible means of saving energy in housing. BRE Current Paper CP56/75 (June 1975).

15. P. Brunt. Economic Factors influencing the choice of collector, ISES-UK Conference Solar Energy for heating Swimming Pools, South Bank Polytechnic, London. (January 1977).

16. CND Stambolis, Survey of Commercially Available Solar Water Heaters in the UK. North East London Polytechnic - Seminar - Solar Energy for Buildings. (February 1976).

17. Solartrap Group, Estee solar water heating kit.

18. D. Turrent et al. Energy Conservation Working Party Report on Solar Water Heating. South London Consortium (ref 17.5 (15)) November 1975.

19. Anon. South London Consortium. Solar Water Heating Test Rig - An Interim Report. July 1976.

20. D.G. Fenter. Telford Development Corporation. Private Communication (August 1976).

21. Anon. Solar Water Heating, ISES-UK (1975) (A new edition is to be published shortly)

22. R.G. Courtney, An Appraisal of Solar Water Heating in the UK. Building 224 (6909) 137 - 139 (Also BRE current paper CP 7/76, January 1976).

23. B.J. Brinkworth, Uses of Solar Energy, Chem. Brit. 11 (9) 311-316 (Sept.'75)

24. D. Hodges, Analysis of the Performance of the Solar House at Milton Keynes, ISES-UK Conference - European Solar Houses, London (April 1976).

25. K. Seymour-Walker. Low Energy Experimental Houses, ISES-UK Conference - European Solar Houses, London, (April 1976).

26. M.Armor, Design & Materials Ltd. Private Communication (November 1976)

27. J.E. Hill et al., Development of Proposed Standards for Testing Solar Collectors and Thermal Storage Devices; National Bureau of Standards for Energy Research and Development Administration. (February 1976).

28. J.K. Page. (Chairman ISES) Discussion (September 1976)

29. A.Eggers - Lura, Flat Plate Collectors and their Application to Dwellings, report (study contract 207-75-9 ECI DK) to Commission of the European Communities. (February 1976)

30. P.Brunt, The Scope for Solar Energy in the Energy Pattern of the Future, 43rd Clean Air Conference, Edinburgh (October 1976).

31. Natural Power (UK) Ltd. (Leeds) Sales Brochure (November 1976).

32. Sun Energy Systems (London) Brochure, (November 1976).

33. NHC Solar Heating (Knutsford) advertisement in The Sun (October 1976).

34. H.Hopmann et al., Development of a 10 kW(e) Solar Thermal Power Station, Solar Electricity Conference, Toulouse (March 1976).

35. Sofretes/Renault Moteurs International, Solar Pump Stations, brochures (1976).

36. J.K.Page, Solar Energy Prospects and their significance for Electrical Engineering, presented to Institute of Electrical Engineers (April 1976).

37. T.J.Connor & P.N.Mathur, Highlight Report - Solar Thermal Conversion Program - Central Power Projects. Aerospace Corporation. Semiannual Review (June 1976).

38. B.McNelis et al. 1MW(el) Helioelectric Demonstration Generating Plant - Design Concept, Technical Feasibility and System Definition. GT Systems Report GT / 75085 / 3, Commission of the European Communities (Nov.'76).

39. J.Ortner et al. Small Solar Power Systems, Austrian Solar and Space Agency, Report AASA FA-3 (August 1976).

40. C.R.Bell and N.Weyss in W.Hafele et al. 2nd Status Report of the IIASA Project on Energy Systems, RR-76-1, (1975).

41. M.Telkes, Thermal Storage for Solar Heating and Cooling, Proc. ERDA Workshop on Solar Energy Storage, Charlottesville, (April 1975)

42. B.McNelis, Interseasonal Solar Energy Storage based on Reversible Chemical Reactions, unpublished work performed for National Research Development Corporation, (1976)

General texts:

- see reference (2) above
- B.J.Brinkworth, Solar Energy for Man, Compton Press 1972
- S.V.Szokolay, Solar Energy and Building, Architectural Press,'75
- F.Daniels, Direct Use of the Sun's Energy, Yale, 1964.

P. G. Sharp

NATIONAL SOCIETY FOR CLEAN AIR

44TH ANNUAL CONFERENCE
19-22 SEPTEMBER 1977
HARROGATE

WHY CLEAN AIR?

PART 1
PRE-PRINTS OF PAPERS

136 NORTH STREET
BRIGHTON BN1 1RG ENGLAND

44th Clean Air Conference
Harrogate, 19 - 22 September, 1977

THE EFFECTS OF AIR POLLUTION ON HEALTH
Professor P.J. Lawther
Medical Research Council

THE EFFECTS OF AIR POLLUTION ON AMENITY
Professor K. Mellanby
Monkswood Experimental Station

WHAT HAS BEEN ACHIEVED AND WHAT REMAINS TO BE DONE - IN THE DOMESTIC FIELD
E.W. Foskett
Director of Environmental Health, City of Manchester

WHAT HAS BEEN ACHIEVED AND WHAT REMAINS TO BE DONE - IN INDUSTRY
C.J.O. Moorhouse
Group Environmental Affairs Adviser, The Rio Tinto-Zinc Corporation Ltd.

THE ENVIRONMENTAL PROGRAMME OF THE EEC AND ITS POSSIBLE EFFECTS ON EXISTING CLEAN AIR LEGISLATION
A.J. Fairclough
Central Unit on Environmental Pollution, Department of the Environment

AIR POLLUTION AND PLANTS
P.J.W. Saunders
Natural Environmental Research Council, London

THE INFLUENCE OF AERIAL POLLUTION ON AGRICULTURAL CROPS
Professor C.P. Whittingham
Rothamsted Experimental Station

EFFECTS OF ATMOSPHERIC POLLUTANTS ON FORESTS AND NATURAL PLANT ASSEMBLAGES
Professor F.T. Last
NERC, Institute of Terrestrial Ecology

RADIOACTIVITY AND THE NUCLEAR FUEL CYCLE
Dr. Roger H. Clarke
Berkeley Nuclear Laboratories, CEGB

THE CONTROL OF AIRBORNE RADIOACTIVE EMISSIONS FROM NUCLEAR POWER STATIONS IN THE U.K.
J. Beighton
H.M. Deputy Chief Alkali and Clean Air Inspector

EXPOSURE TO THE PUBLIC TO RADIOACTIVE DISCHARGES FROM THE NUCLEAR FUEL CYCLE
Pamela M. Bryant
Senior Environmental Adviser, National Radiological Protection Board
and
Frances E. Taylor
Senior Scientific Officer in Environmental Studies Group,
National Radiological Protection Board

NATIONAL SOCIETY FOR CLEAN AIR

44th CLEAN AIR CONFERENCE

SEPTEMBER 19 - 22, 1977

HARROGATE

THE EFFECTS OF AIR POLLUTION ON HEALTH

Professor P.J. Lawther
Medical Research Council

136 North Street
Brighton BN1 1RG
England

The founding fathers of the Society would surely have been amazed had they witnessed the frenzied concern about air pollution which has grown as the concentration of coal smoke has declined. Some of us today wonder at this paradox that clamour about pollution is sometimes inversely proportional to its concentration. But there is no apathy among those who investigate the effects pollution might have on health; the problems have altered radically in the last 25 years and new approaches must be tried.

In the bad old smokey days there was little difficulty in demonstrating the effects of coal smoke and its attendant sulphur compounds on morbidity and mortality even though the specific pollutant responsible (if there ever was but one) remains unidentified. It is not hard to see how such an irritant miasma could act. The implementation of the Clean Air Act and the application of common sense have produced a dramatic change which strangely is all too seldom praised in our hunt (sometimes masochistic) for yet more environmental evils. A most welcome consequence of the dramatic change in the environment is that it is now extremely difficult to demonstrate any effects of pollution on health; this failure of our techniques does not mean that pollution of the ambient air is having no effect - but that the "signal to noise ratio" is so low that effects are submerged.

Even if there were no humanitarian reasons for continuing research on the effects of pollution on health there would still be an urgent need for work to test the validity of the grounds on which air quality guides, criteria and standards are being set in other places. Some would maintain that, however welcome, convenient and proper is the use of standards in industry for the protection of healthy workers,the application of standards to the general population living in widely varying circumstances is, if not wholly impracticable, at least very expensive. To recognise the economic implications of pollution control is not to be cynical; to fail to count the cost would be sentimental and bad medicine.

The pollutants selected by those who would set standards compromise at present particulate matter, sulphur oxides, oxides of nitrogen, carbon monoxide, polycyclic hydrocarbons and lead. (In some countries there appear to be standards for almost every compound.) One might be forgiven for occasionally wondering why some of these compounds were selected for special prohibition since there is so little evidence to support the contention that, in the concentrations commonly found, they have any discernible effect. Of course, in high concentration they have effects (as do any pollutants) but extrapolation, whether it be in terms of dose or concentration, or from the observed effects on animals to supposed effects on man, is fraught with danger.

The paper will be concerned with the special needs for caution in applying the results of current research and with the difficulties in designing future work so that it may be used to justify action which might be very costly indeed.

NATIONAL SOCIETY FOR CLEAN AIR

44th CLEAN AIR CONFERENCE

SEPTEMBER 19 - 22, 1977

HARROGATE

THE EFFECTS OF AIR POLLUTION ON AMENITY

Professor K. Mellanby
Monkswood Experimental Station

136 North Street
Brighton BN1 1RG
England

We have heard from Professor Lawther how air pollution can be a health hazard, and how this danger has been reduced in urban areas where the pollution has been, to some extent, controlled. I am concerned with the other environmental effects of air pollution. My title refers to "amenity" - a word defined by the dictionary as "the quality of being pleasant or agreeable". If the air is foul then amenity is destroyed, for the environment is neither pleasant nor agreeable. I propose to examine some of the ways in which this damage is done, and to describe the reactions of various organisms to the state of the atmosphere.

Before the war, I lived in Sheffield, a city which at that time had the great virtue that it was easy to escape from its squalor to the Derbyshire moors. The change was a very pleasant one, but it did not allow the traveller to escape entirely from the air pollution produced in Sheffield to the east and in Manchester and its satellites to the west. The moors were beautiful, but they were very mucky. The grazing sheep were all apparently black, and if you sat down on the heather your garments were soon streaked with dirt. Visiting the same area recently I saw a great change. The sheep were not exactly glistening white, more a sort of pale gray colour before they were shorn, but the heather was reasonably clean. There had clearly been a remarkable improvement in the amenity of the locality. Of course, within the city of Sheffield itself, the change was even more dramatic. The sun seemed to shine all day long, and views stretched for miles where formerly only fog and smoke was visible.

There is thus little doubt that the reduction in the emissions of smoke which have occurred over the last twenty five years have had remarkable effects in improving amenity in both urban and rural areas in Britain. There are still too many local pockets, including most of the coal mining districts, where due mainly to the miners' concessionary coal, things are still unsatisfactory, and there is a risk that, following the rise in oil prices and stimulated by fears that oil reserves will be soon exhausted, increased use of coal will be allowed to pollute the atmosphere once more in what are now smokeless zones. I am glad that your Society and other bodies, including the Council for Environmental Science and Engineering, are aware of this risk, and are doing all that they can to prevent any sort of return to the situation of 1952.

Smoke may be largely controlled, but there are many other forms of air pollution which may affect our environment. These include sulphur, fluoride, the many substances included in the exhaust gases from motor vehicles, carbon dioxide and the various smells which arise from both industry and agriculture. And, of course, tobacco smoke. The effects of all these on amenity must be examined. At this point I must apologise in advance to other speakers if I trepass slightly on their territory. I shall try to confine my remarks to my subject - air pollution and amenity - but it will be impossible to avoid some reference to topics such as agriculture, and to the effects of pollutants on plants and on animals. It It is the same air, clean or dirty, which affects all our activities, and it is difficult to divide the whole subject up into tidy compartments.

Sulphur, mostly in the form of gaseous sulphur dioxide,is,quantitatively

the most important air pollutant produced by human activities in Britain today. Over five million tonnes are discharged into the air annually. While the discharge of smoke has decreased so greatly, that of sulphur actually rose in the late nineteen fifties and early sixties, and has fallen only comparatively slightly since. However, an increasing proportion is now discharged from high chimneys, so that ground level concentrations in urban areas are often lower today than twenty years ago. Levels in rural Britain were expected by some to rise, but there is little evidence that this has happened; in fact they have fallen substantially in my part of East Anglia in the last five years. But as will be known to all present, it is suggested that a substantial amount of our sulphur is being exported in the air to harm fish, amenity and possibly timber production in Scandinavia.

Sulphur differs from some pollutants which are undesirable even at very low levels in that it is one of the elements essential for the continued existence of life on this planet. Essential amino acids which go to make up protein contain sulphur; for every 14 nitrogen atoms in protein, one atom of sulphur must be present. Sulphur must be present in the soil for plant life to be possible. Before man, and his agriculture, transformed so much of the surface of the globe, sulphur levels in the soil were maintained by the breakdown of rocks and by deposition from the air. Most of the sulphur in naturally-growing plants was returned to the soil when these plants died and decomposed. There was a reasonably steady balance which was maintained by these processes. Now man has upset this balance. He discharges into the air, and though his emissions are, in total, less than half of those occurring naturally, they are concentrated into a tiny fraction of the whole of the earth's surface, where their effects are correspondingly greater. At the same time man removes large weights of crops from his farmland, and these contain substantial amounts of sulphur, sufficient to deplete the natural reserves even when these are augmented by aerial deposition in unpolluted areas.

It is rare, even in industrial areas, for levels of sulphur dioxide to be sufficiently high to inconvenience man himself, but other organisms are frequently affected. It is well known that many species of lichens are particularly susceptible to damage, and may even be used as "biological indicators". It is the raised levels of sulphur in the atmosphere which turn our cities into "lichen deserts" and which prevent the delicate, foliose lichens from growing in many parts of rural Britain. They only flourish in the South West where the prevailing winds arrive from over the Atlantic ocean.

The question is, does this matter? Is the loss of the lichen flora an indication of a serious loss of amenity? No doubt this could be argued by the botanist and by the conservationist, and I have in the past suggested that if one type of living organism is being damaged, then others may be suffering undetected harm. I have even suggested that our aim, in controlling pollution, is to produce "air fit for lichens" in the certainty that this will also be good for man and his activities.

Unfortunately this may be an oversimplification of the situation. Somewhat

raised levels of atmospheric sulphur dioxide may have some desirable effects. There is evidence that on some sulphur-poor soils crop yields may be improved by aerial deposition of sulphur, and that farmers may be saved the expense of adding the element in their fertiliser. We also know that some plant diseases caused by fungi were kept in check in urban areas by raised levels of sulphur dioxide which appeared to cause little damage to the host plants. Thus the Black Spot disease of roses was unknown in most urban gardens; it has reappeared as the air has become cleaner. The same is true of the disfiguring Tar Spot disease of the sycamore tree. We thus see that a level of sulphur dioxide which may be thought of as "pollution" from the point of view of a lichen may be, if anything, too low when we are considering some crops or the control of their diseases. If roses are diseased, and therefore less beautiful, is amenity damaged? Do we consider lichens more important than sycamore trees? Many of our decisions must be subjective rather than scientific.

It would appear, then, that sulphur emissions do not do a great deal of damage in Britain. However, it is suggested that this is because we export our pollution to damage the conditions in Scandinavia. This is a complicated subject which deserves some consideration. First, it should be noted that, under all conditions, the air in Britain has much higher levels of sulphur dioxide than those found in Norway and Sweden. In Southern Norway, where damage to rivers has been reported, foliose lichens flourish more vigorously than they do in most parts of the British Isles. Secondly, much more of the sulphur produced in Britain is deposited within our own territory than is ever blown over the sea to Scandinavia. Yet the small amount which is so transferred probably has quite important biological effects.

The main reason for this difference is that the geology of the two regions is different. In Britain large areas are covered by calcareous rock, and much of our freshwater is "hard" with a considerable buffering capacity. It can assimilate a good deal of acidic material without unduly reducing the level of the pH. In much of Scandinavia the rocks are granitic, and the freshwater has little buffering material, so a small addition of acid reduces the pH below the level where fish, particularly trout and salmon, can survive. The situation is made worse by the climate. All the rain which falls during perhaps six months of winter is "stored" as snow; the pollutants in the rain, and other materials deposited on its surface, are accumulated over that period. In spring, when the thaw begins, the snow becomes saturated with water. When this happens most of the pollutants come to the surface and are contained in the first melt. This is sometimes found to consist of decinormal sulphuric acid. The soil is still largely frozen, so this very acidic water runs over it into the streams, with drastic results.

Quite naturally, the Swedes and Norwegians resent their countries being the dumping grounds for sulphur from Britain, Belgium, Germany, Czechoslovakia and Poland. They wish us to reduce our emissions. Yet we can accept larger amounts than ever reach their shores and ourselves suffer so little damage. Should we then incur great expense to try to preserve their amenities? It has been suggested that if only a few tonnes of lime were

added, at the appropriate times (and possibly at the expense of the polluting nations) to their rivers, the damage would be avoided. Incidentally, there are records of acidity occurring in some Norwegian rivers in the nineteenth century, caused by the accumulation of natural sulphur emissions, and of the use of lime to safeguard the fish stocks; so this would not be an entirely novel solution.

Furthermore, even in Scandinavia the sulphur is not entirely damaging, for some of the agricultural soil can easily become depleted of this material and crops may be improved by the depositions which are harming fish in the same countries. One man's meat is clearly another man's poison!

In many parts of the world, buildings are being damaged by acid depositions and acid rains. These often arise from burning sulphur-rich fuel oil. Recently publicity has been given to the damage to the stones of the Parthenon in Athens, and the Greek Government is trying to enforce the use of low-sulphur oil in their capital.

There is very little evidence of damage to the wild flora and fauna, except to lichens and to fish in very "soft" water, from sulphur pollution, but this does not mean that it does not occur. Fungi are very easily damaged by sulphur (hence the control of Black Spot in roses) and they may be affected in natural and also in agricultural areas. The results may be more serious than is generally expected. The disappearance of a few toadstools would hardly be considered a serious degradation of the amenities, but we are now finding that the growth of many higher plants, particularly in rather infertile soils, is considerably enhanced if they enter into a mychorrhyzal association with the hyphae of a wide variety of fungi. It may therefore be wise for us to be more concerned than present evidence would suggest is necessary about the effects of sulphur in the atmosphere. It may be better to keep the levels in the air, even if we have to raise levels in some agricultural soils by applying suitable chemicals as fertilisers.

Fluoride, from aluminium smelters and brick works, has been found to have serious damaging effects to vegetation and to livestock in an area within a few kilometres from the source. A new smelter in a previously unpolluted area has eliminated lichens and killed trees in its near vicinity. Clearly there would be serious damage to amenity if this occurred in a populated area, and every effort should be made to reduce the effects even in a very rural neighbourhood.

There is widespread concern about the harmful effects of the exhaust gases from motor vehicles. There is no doubt that, whatever their advantages, motor vehicles damage our amenities. They clutter up our towns; permanent rows of parked cars destroy the appearance of many streets and city squares; vehicle noise is often intolerable. In addition, cars pour out toxic substances, including carbon dioxide, carbon monoxide, oxides of nitrogen, ozone, unburned hydrocarbons and lead. Under suitable conditions and at high enough levels, these can clearly harm the amenities. Thus in California where large gas-guzzling cars abound, and where temperature inversions with high sunlight intensities are common, exhaust

emissions produce photochemical smog which is harmful to plants and irritating to man. Similar reactions, but of a lesser intensity, have been reported in other areas, though not at significant levels in Britain. Nevertheless we have now had reports of phytotoxic levels of oxidants during hot, still weather, and so it would be wise for us to move towards even smaller and cleaner, and a more efficient use of our transport. The depletion of oil reserves may solve this problem for us.

There is little hard evidence that the other pollutants in car exhausts have many harmful environmental effects. There has been some concern about the possible effects of lead, but these have probably been exaggerated. Oxides of nitrogen have seldom been reported at toxic levels. Carbon monoxide levels in the air are raised, but those who breathe these in our most crowded streets have lower levels in their blood than do moderate smokers of cigarettes. Yet the smell of petrol fumes, even if not damaging to health, is unpleasant. Too many cars damage amenity in a great many ways.

Diesel engines, when properly maintained, give out little in the way of pollution, but they do produce a characteristic and nauseating smell. This is particularly noticeable in railway stations where diesel locomotive engines seem to be kept running for very long periods when the train is stationary. This produces a very unpleasant environment, made even worse, if you are sitting, waiting, in the train, by the intolerable vibration.

Burning coal, oil and natural gas - the various "fossil fuels" - liberates carbon dioxide into the atmosphere. This carbon originally came from the air, and was stored over a period of many millions of years. Today we are burning these stores many hundred times as rapidly as they were laid down. There is some, not entirely conclusive, evidence that this process has already raised the level of carbon dioxide in the atmosphere by some twenty per cent.This has probably had little effect;it may have made plant photosynthesis slightly more efficient. However, a substantial increase in the level of atmospheric carbon dioxide could have an effect on the climate of the world. It is believed that it would have a so-called "greenhouse effect", allowing the radiation from the sun to penetrate the atmosphere, but trapping the infrared radiation as it leaves the earth's surface. This would raise the world's temperature, something that we in Britain might think would improve our amenities. However, the result might be catastrophic if it melted the polar ice and raised the level of the sea sufficiently to submerge London and most of the other capital cities. This result is still problematical but it is generally agreed that it would be unwise to increase our use of fossil fuels, including coal, by a factor of more than two before we have fully monitored the possible effects.

Objectionable smells, in many situations, often seriously damage amenity, and may be impossible to control. We deplore the waste of the potential manure produced by farm animals, but when the slurry is spread on the fields the whole countryside becomes uninhabitable.Life on the windward side of a piggery or of a collection of intensive poultry houses is intolerable.Many industrial processes produce the most awful stinks.It may some-

times be possible to take legal action and prevent these abuses,but this is often costly and difficult. Smells are intermittent, and may be absent when the inspector calls. It is often difficult to prove that real damage has been done, and different people have very different thresholds. Yet I have known several people who have been driven from their homes by the smells produced by their neighbours. This is one of the problems which require most study today.

Finally we have tobacco smoke. We know that, from the health point of view, this is by far and away the most serious form of self-inflicted atmospheric pollution. For the non-smoker, it is also the most serious way in which the amenity of our immediate environment may be destroyed.

NATIONAL SOCIETY FOR CLEAN AIR

44th CLEAN AIR CONFERENCE

SEPTEMBER 19 - 22, 1977

HARROGATE

WHAT HAS BEEN ACHIEVED AND WHAT REMAINS TO BE DONE - IN THE DOMESTIC FIELD

E.W. Foskett
Director of Environmental Health
City of Manchester

136 North Street
Brighton BN1 1RG
England

domestic smoke came to ground within short distances.

In cold weather pollution from domestic sources increased because of greater fuel consumption and the inability of the smoke to disperse to the upper atmosphere.

(vi) When coal, coke or oil was burned whether in industrial or domestic appliances sulphur dioxide was a component of the flue effluents.

The Clean Air Act 1956 (3) became law in July 1956. This Act was "to make provision for abating the pollution of the air" and to achieve its objectives an approach on four lines was proposed. Firstly, to deal with industrial pollution the emission of dark smoke was to be regulated, and, secondly, within the limits of practicability new furnaces were to be capable of being operated smokelessly, thirdly, grit and dust arrestment was to be achieved by the best practicable means. Fourthly, to deal with domestic smoke pollution, powers were given to local authorities to set up smoke control areas to reduce smoke from dwellings.

Extensions of the pollution control provisions of the 1956 Act were brought about by the Clean Air Act 1968 (4) the Health and Safety at work etc. Act 1974 (5) and the Control of Pollution Act 1974 (6).

No excuse is offered for restating the main conclusions of the Beaver investigation because the inquiry formed the basis of all subsequent activity. Neither is it profitable to attack the Beaver Report with the benefit of hindsight for in many ways it anticipated some of the difficulties which would arise, but it is worth noting that the Committee was confident that the results it looked for would be beneficial, and that the cure would cost less than inaction. There were, however, no illusions that the target could be reached without entailing cost and sacrifices, though their idea of costs for domestic smoke control, based on about £6 per grate, were even then unrealistic. The Committee however recognised that a national effort and a continuous programme was needed.

It is unfortunate that major Committees of enquiry frequently manage to work out a satisfactory philosophy but fail to suggest an equally satisfactory machinery to achieve the goals of the philosophy. Such a plight affected the outcome of the Beaver Report. The Report was written a decade after the end of the War when the nation seemed to be emerging from privation, stringency and shortage into a much sunnier economic climate. The Beaver Committee cannot be blamed for failing to forecast the economic constraints which were to come or the rapidity of technological change which produced such dramatic changes in the scene. To look for such matters was outside their terms of reference and those who perhaps should have noted the trends appear at least not to have been heard.

The concept of the smoke control area was not new, although pioneers had originally developed the idea of smokelessness as opposed to smoke control. The idea of smokeless zones appears first to have originated as a practical proposition in Manchester in 1935 by Mr.Charles Gandy, Chairman of the National Smoke Abatement Society. The idea was pressed on the Manchester

City Council by the Society and in 1938 the first steps were taken to survey a large central area of the City and reported in detail in December 1939. The implementation of the scheme was curtailed by the outbreak of the War, and it was not until 1946 that the appropriate statutory powers were obtained for the creation of smokeless zones, and it was not until 1954 that the first smokeless zones began to be created in Manchester although this again was ante-dated by some few months by the City of Coventry.

It is important to note the passage of time. 20 years eleapsed between the propagation of the idea of smokeless zones and the first appearance of such means of controlling smoke from domestic sources. A further 20 years has elapsed so that a review of progress made towards reducing atmospheric pollution is not out of place, especially as the Beaver Committee believed that twenty years was sufficient to make a major impact on the problem of air pollution.

It is generally conceded that substantial progress has been made in the reduction of visible and invisible pollution in the atmosphere. The major sucess has been on the industrial and commercial scene where, clearly, the economies of reduced pollution have been learned, especially, by cost conscious companies. What remains, however, is the fact that despite the twenty years availability of powers to make smoke control areas it is estimated that 85% of current smoke pollution of the atmosphere still derives from domestic sources.

If we look at the progress table produced by the National Society For Clean Air recording the situation at 31st March, 1977 (Table I) (7) we can summarise the position thus (Table I).

TABLE I
ENGLAND

Smoke Control Areas Confirmed			
Orders Confirmed	4744		
Acres Controlled		1,571,090	
Premises Controlled			6,869,019
Smoke Control Orders Submitted			
Orders Submitted	35		
Acres in the Orders		30,349	
Premises in the Orders			63,146
TOTALS	4779	1,601,439	6,927,165
	Orders Confirmed or Submitted	Acres Within the Acres	Premises within the Areas

In addition to the above noted action taken under the Clean Air Acts, some 3,400 acres and 41,600 premises are controlled by Smokeless Zones implemented by local authorities having local Act powers.

Looking at three other tables (Tables 11,111 & IV) a pattern emerges.

TABLE II Authorities within the Greater Manchester County Area. (All Members of Manchester Area Council for Clean Air and Noise Control). Data to 31.12.77.

No. of Authorities	No. of Premises	No. of Premises under smoke control	% of total	Acreage	Acreage under smoke control	% of total
10	1,090,140	763,756	70.06	321,058	184,550	57.48

TABLE III Authorities outside Greater Manchester Council Area but members of the Manchester Area Council for Clean Air and Noise Control

4	193,783	73,304	37.83	340,441	41,096	12.01

TABLE IV All authorities within the area of the Manchester Area Council for Clean Air and Noise Control

14	1,283,923	837,060	65.19	661.499	225,646	34.11

The national picture with regard to pollution is to be found in the statistical tables produced by the National Survey of atmospheric pollution conducted by Warren Spring Laboratory of the Department of Industry.

From these tables and other data, Warren Spring has constructed contour maps for the whole country showing smoke and sulphur dioxide levels. Because of the uneven spread of the recording stations the results cannot be regarded as being absolutely precise but are sufficiently accurate as to give a good picture of the current pollution picture of the United Kingdom. The picture is like the Curate's egg - good in parts. In parts it is bad and there are regions such as the North West, North East, Midlands and the Clyde/Forth Valley in Scotland which, in terms of pollution levels, are disadvantaged when compared with other areas of the country.

The figures indicate widely varying levels of pollution within the various regions but high pollution levels occur in inner city areas so that, again, there is the evidence of environmentally deprived areas also being the areas worst hit by pollution.

Not all the smoke control orders are within the areas of the so called "black areas" but clearly many are. Almost 7 million premises are subject to control and it may be assumed that 90% of the premises are used for domestic purposes so thaton that basis about 6.4 million houses are subject to smoke control orders and that figure is approximately 40% of the total number of dwelling houses in England.

What is not revealed by these figures is the percentage of domestic premises covered by smoke control in authorities in the former "black areas", and what percentage relates to authorities in the "White areas".

It is apparent, however, that having regard to housing densities in urban areas the smoke control areas noted in the table must contain large areas of open land.

It is surprisingly difficult to catalogue precisely the effects which pollution control has had. There have been clearly marked benifits, some of which can be described effectively. In the case of some relatively small areas of the country useful comparisons of long term consistent data can be made but in many cases, such data is absent or available only for shorter terms of years. The figures and maps produced by the National Survey are useful as indicators and show trends, but variations in the data bases make absolute comparisons difficult.

Additionally, it is not easy to make an accurate assessment of the relative contributions to the improvement of the various sectors of combustion-produced pollution. Thus while it is not easy to quantify improvements due to improved air quality they are apparent.

In areas where the atmospheric pollution is measured, long and short term measurements of both smoke and sulphur dioxide show improvements. What is often startling is to measure the decreases in pollution levels in areas not subject to smoke control after adjacent areas have been subject to such control. If proof was needed of the value of smoke control action it is to be found in such ways. Not all the decreases in the level of pollution in such areas are attributable entirely to reduced pollution in-drift. Making a contribution to the decrease of pollution in non smoke-control areas is the demolition of unfit houses and voluntary changes to smokeless house heating.

The reduction in pollution levels in urban areas subject to domestic smoke control - which, substantially, is the consequence of the smoke control area policy - is often dramatic. In Manchester for example the winter daily averages have been reduced by 83% for smoke and by 62% for sulphur dioxide since 1959 (8). In some parts of the City the reduction is much greater than that and further overall improvement is expected as the smoke control programme is completed. Many local authorities have adopted

pollution level targets and these are usually those recommended by Professor Lawther and/or the W.H.O. The former are short term targets relating to winter daily averages and the latter to long term goals for annual daily averages. The following Table shows what had been achieved by the end of 1975 in 9 of the 10 measuring Metropolitan Districts in the G.M.C. area. (9).

TABLE V

Authority	No. of Stations Measuring both factors	Short term target in micrograms per cu.metre		Long term target Annual daily average in Micrograms per cu.metre	
		Smoke 100	SO2 150	Smoke 40	SO2 60
		No. Achieving Target	No.Achieving Target	No.Achieving Target	No.Achieving Target
A	11	11	11	2	NIL
B	4	4	4	1	NIL
C	8	8	6	5	NIL
D	12	12	12	9	NIL
E	7	7	6	1	NIL
F	6	6	6	5	NIL
G	4	4	4	3	NIL
H	3	3	2	2	NIL
J	7	6	6	2	NIL

As these may be taken as typical authorities from heavily industrialised and urban areas it will be seen that the performance in respect of short term targets is good and even in the case of longer term goals the authorities are approaching the levels needed to achieve the W.H.O. smoke pollution level but there is cause for concern with regard to the sulphur dioxide figures.

Although Table V indicates a fairly encouraging picture three factors need to be noted. Although many of the readings are within the target level many of them are not so significantly better that an adverse winter might not push them to the target datum. Offsetting that, however, is the fact that these results are being achieved with only about 70% of the premises within the areas subject to smoke control orders. As the percentage of premises under control rises the effect within, and without, the individual districts will be for target figures to be more easily achieved.

The third factor, the emission of sulphur dioxide, is more worrying, especially in the long term, and this pollutant is less easy to control than smoke emissions. Rising standards of domestic heating, accompanying rising living standards, may have the effect of raising the amount of fuel used unless such higher standards are the consequence, at least in part, of better heat conservation.

The measurement of atmospheric pollution as part of the National Survey produces at least some quantitative evidence of the benefits of smoke control. Other quantitative evidence is available from meteorological records. Up to the years of the early 1950's clarity of the atmosphere in the urban areas was usually a symptom of the annual town holiday, economic depression or strike action. Normal life was a true reflection of the axiom "where there's muck there's brass". Industrial areas were notorious for their impenetrable fogs. Smoke control has banished the "London particular" and in other areas has decreased "smog" and increased sunshine at ground level - both factors being measurable.

If comparison is made between 1931 - 1957 and 1961 - 1970 the available sunshine in the city centre of Manchester increased overall by about 12% . Much more startling was the 47% increase in winter sunshine and the respective increases in November, December, and January, of 40%, 88% and 60%. C.H.Wood in his paper "Visibility and sunshine in Greater Manchester" (10) wrote "The striking improvements in the city centre (particularly with regard to less dense fogs) is almost certainly due to the effect of smoke control" and"the evidence that the marked increase in sunshine is due to decreased pollution readings is thus extremely strong".

It is of course a reasonable expectation that reduced particulate matter and sulphur dioxide in the air would allow more sunshine to penetrate, promote more turbulence and assist in better dispersal of pollutants.

The apparent improvements in meterological conditions frequently astonish vistors, returning from overseas, who are able to make comparisions from personal experience spanning many years. It is, however, satisfying that the subjective external appearances are confirmed by scientific measurement.

There can be little doubt that in the last twenty years the greatest single improvement in the urban environment has been the reduction in atmospheric pollution. In comparison with rural living the town dweller has many advantages but also many disavantages not least of which has been the environmental disadvantage of air pollution. This disavantage has been progressively reduced by each advance in air pollution control.

The physical effects of smoke control are also fairly easy to demonstrate. The decoration of houses is subject to less soiling and the changes in the colour schemes of external house decoration reflect improved air quality as well as changes in social taste and paint technology. Buildings cleaned externally now remain clean and will never return to their former murky hues. Where former smoke-stained areas were left uncleaned on buildings the contrast with cleaned masonry and brickwork is most marked.

Physical improvements such as those noted above appear to have been accompanied by biological benefits. Attempts have recently been made to correlate the decreased atmospheric pollution with a decreased mortality from bronchitis which has always been a scourge of the industrial areas in the United Kingdom. It appears that some relationship may be demonstrated although it would be prudent not to read too much into the results until further examination of the factors involved assigns appropriate credit to the various aspects of the decreased bronchitis death rate.

Other biological progress is also to be noted although, again, the judgement is subjective rather than objective though fairly easy to demonstrate. Better plant growth is demonstrable in a number of ways and favourable reaction to improved air conditions has been noted in species of insects, and it is thought that cleaner air may have contributed to the noted increase in some urban areas of species of birds probably attracted by increased numbers of insects.

Academic studies show a close correlation between polluted air and corrosion. Such corrosion is almost inevitably very costly and any reduction in such costs are welcomed by industry.

In 1974 the Department of the Environment published the pamphlet "Clean Air Today" which contained the view that " of all aspects of air pollution control, domestic smoke control remains the best value for money and the most necessary and efficacious". (11).

In "Controlling Pollution" (12) Anthony Crosland wrote in 1975

"I note, however, that some concern is expressed over the rate at which smoke control is being implemented in some areas. I share this concern. While fully recognising that economic difficulties currently facing local authorities may delay progress in the short term, I would like to see improvements in the longer term".

Since the Beaver Report was written several important aspects, inadequately considered by the Committee, have emerged. Firstly, it is now clear that insufficient emphasis was placed on the effect of the drift of aerial pollution. More sensitive methods of monitoring and sophisticated ways of assessing effects of pollution have shown the wide drift of pollution and the incremental effect of such pollution drift. The significance of this is that pollution has an immediate local effect, a wider neighbourhood effect, a regional or sub-regional implication, and an effect on the totality of the national pollution picture. Indeed reference to the "Observer" newspaper on Sunday July 10th 1977 (13) shows that pollution is no respecter of international frontiers. Pollution knows no boundaries other than the ever changing barriers of meteorological conditions.

Because the Beaver concept was for a national effort to deal with atmospheric pollution it can be assumed that while the principle was understood its importance was not sufficiently stressed. While the "black area" approach was a satisfactory pragmatic introduction to the campaign the

isolationist and ego-centric policies of individual local authorities has been permitted to persist for too long. In particular the removal of the distinction between "black" and "white" areas was too long delayed. (Circular 131/74) (14).

The easily observed fact that domestic smoke pollutes the immediate neighbourhood of its source and then flows on to pollute other places suggests that, while the concept of the smoke control area is one well suited to both administrative convenience and the practical implementation of a scheme which must proceed incrementally, the decision to leave the creation of such areas to the whim of local authorities was a move calculated neither to maximise the benefits of reduced pollution, nor to ensure an orderly, and planned, approach to the whole matter.

As the years have gone by this approach has revealed a not unusual paradox. Central Government had, and has, an obvious interest in the most speedy completion of the smoke control programme because it grant aids part of the cost directly and gives, through rate support grant, indirect assistance towards meeting the cost which local authorities themselves incur. Delay adds to the cost of converting appliances, adds to the ultimate concealed cost of the operation by prolonging the maintenance of staff to administer the scheme, and has cost Central Government a great deal.

Especially regrettable has been the recent delay imposed by the Department of the Environment on the establishment of smoke control areas by post-poning the confirmation of smoke control orders. The implementation of these relatively modest items of capital expenditure will, in consequence, be more expensive.

An alternative process might have been to have adopted an"eradication" scheme, analogous to those used to combat animal disease, with simultaneous starts in every major area of high pollution. In some areas, of course, local authorities co-operated through locally established pollution control committees, although these have been the exception rather than the rule.

Although the Beaver Committee recognised the need for a national effort it seems to have assumed that little direction would be needed to secure the national effort. That is not to say that it was not right to entrust the work to local authorities. It should be a cardinal principle of pollution control that the executive authority should be the one elected to protect the interests of the local public. This principle was properly followed but what has been lacking is persistent central pressure. Had the latter been the case, then many local authorities who failed either to recognise they had a pollution problem, or to generate the will to tackle what they recognised, would have been more likely to have made a greater contribution to meeting the national need.

Having said that, nothing should detract from the superlative, positive, policies of many local authorities to reduce domestically produced air pollution.

Inadequate consideration was given to the fact that a clean air policy is

easier to sustain if it accompanies a fuel policy which itself recognises the importance of clean air. Indeed, the rags of any 1956 fuel policy are matched by the tatters of any 1977 fuel policy. Any Committee of enquiry faces difficulties when it tries to evaluate likely innovation, technological and social changes affecting its field of enquiry. In 1956 thoughts were still on cheap fuel although the fuel of choice was oil and not coal. But the foundation of the clean air campaign was coke from the coal-based, but then declining, gas industry and by the early 1960's the policy was in ruins. By the early 1970's the shortage of gas coke led to the need for Suspension Orders being made to keep householders within the law.

The concept of clean air was directed towards the improvement of the environment in which social life exists but it failed to give cognisance to the facts of changes in social attitude and for too long official policy failed to recognise that more and more people would want their heating to be at the turn of a knob or switch. Solid fuel became a less acceptable form of heating.

Another aspect of domestic smoke control which was not anticipated was the brake placed on its development by administrative difficulties, changes in government policy and the impact of financial contraints.

In efforts to systematize the process of establishing Smoke Control Orders, flow charts which have been devised show that up to 50 essential steps need to be taken. The process is, thus, not simple, and the complexity arises principally from all the legal and financial processes which are involved. Fortunately, relatively few Smoke Control Orders have been taken to Public Inquiry but when these have been necessary a considerable additional effort has been incurred.

Local authorities creating smoke control areas have, in some cases, been unable to take full advantage of continued experience because advice has changed. As an example of this we may look at Section 12 (2) of the Clean Air Act 1956 where there are provisions enabling the service of notice requiring the execution of works of adaptation. This power is not qualified by a time limit but the Department of the Environment advised that it was not appropriate to serve notice more than twelve months after the operative date although they would consider exceptional cases individually. The view may be taken that this was an arbitrary decision designed to reduce expense marginally. Better progress might have been made if discretion was left to the local authority. In some larger local authorities a smoke control area may contain 10,000 dwellings or more and in a closely knit urban community affected by redevelopment, road schemes, tenancy changes etc. these would present a wide variety of personal and community problems, and it is clear that to secure Ministry approval to each notice which arises after twelve months is an extremely cumbersome practice.

Section 34 (6) of the Clean Air Act 1956 refers to "works reasonably necessary to make suitable provision for heating and cooking without contravention of a Smoke Control Order", but the Ministry of Housing and Local

Government Memorandum on Smoke Control Orders (15) said "cost should be judged reasonable if it corresponds broadly with the cost of appliances in houses provided by local authorities". This did not take account of the very favourable bulk purchasing rates available to local authorities which could clearly prejudice the grant level available to the private householder.

There was also disagreement with the Ministry in the early days with regard to installation costs. They found it difficult to recognise the different cost structure involved between new work and jobbing work. Eventually both these problems were resolved by the Ministry issuing circulars specifying maximum cost levels for appliances and, in the Manchester area by the effort of joint authority committees in producing schedules of installation costs based on local labour and materials charges. Despite this there is recent local experience of an appeal to the Local Government Commissioner on the grounds that tiled surrounds were not available at the price quoted, although how far one should bend in relation to what local suppliers are prepared to stock is a vexed question.

The original basis of domestic smoke control was the combustion of gas coke on coke grates. The disappearance of gas coke led to the extension of the grants system to cover hard coke appliances. However, open-fire fuels are again available, principally from the private manufacturers; the wheel has turned full circle, those house already equipped with coke grates cannot qualify for grant and many residents will be dissatisfied. Delays have checked progress both locally and nationally, and, after all their waiting, the householders must keep their coke grate and not get the gas fire which they expected from the Council or, in the case of private houses, would have installed perhaps two years ago.

The implementation of a Smoke Control Programme has been markedly influenced by circulars issued by the appropriate Ministries. Doubtless, the Ministries have intended these circulars to be advisory and for guidance. In many cases, and especially in financial circles, the circulars have acquired the authority of Holy Writ to be disregarded at peril. The circulars have not been free from ambiguity and this has affected the interpretations which may be made. Circular 54/76 (16) says that it is no longer reasonably necessary to pay grant towards the cost of replacing improved open grates which are capable of efficiently burning currently available smokeless fuels. Does this imply that they are all efficient, or that some are more efficient than others? In any event, the evidence is that they are all relatively inefficient. SFAS figures quote 40% efficiency for an open fire, 65% for an openable stove. The circular was doubtless intended to conserve finance but paid scant regard to the urgent need of fuel conservation.

The most serious cause of non-fulfilment of smoke control area programmes is almost certainly due to local authorities giving smoke control insufficient priority. Despite periodic ministerial exhortations there has not been the consistent pressure from the centre needed to achieve results, regardless of persistent advocacy by the National Society for Clean Air and similar bodies. On each occasion of financial stringency smoke control

programmes have appeared ripe for pruning, postponement, or abandonment. In recent years the financial climate has been made chilly for domestic smoke control with the contents of White Papers etc. tending to encourage delay and procrastination.

From Circular 171/74 (17) there is in paragraph 39 the following comment "the Government accept that for the year ahead local authorities may not be able to undertake any more development in the field of smoke control" this was interpreted in various ways, some Councils taking the advice literally and others using it as a reason for reducing smoke control. However, in the Circular 120/76 (18) guidance is given by saying that " Environmental Services continues to be an area where local authorities are expected to determine their own priorities. These are, however, some services connected with the maintenance of food and public health standards and the enforcement of existing environmental health legislation which authorities will need to maintain tc a basic standard". In the Command Paper 6393 (19)the local environmental services are defined and included smoke control. Thus there appears to be a clear indication that while Central Government suggested contraints in the environmental sector local authorities had always the power to proceed with smoke control if they had the will.

This approach is to be deprecated. Smoke control produces obvious improvements in public amenity. The cost per capita of the population is a small payment; the value of the improvements due to a cleaner atmosphere are of lasting benifit to which can be assigned no monetary value. To delay domestic smoke control further is shortsighted and produces additional avoidable costs. Most local authorities have specialised staff engaged on this work. The cost of this staff is borne as a revenue cost and tends still to be expended, at least in part, even if the progress of the programme slows down to a crawl. It makes sense to complete the programme at lower costs this year than they will be next year, or the year after, and to redeploy the staff on other environmental health functions after the programme is completed. Additionally, domestic smoke control ought to be contributing to national well being by assisting in fuel conservation and adding to amenity.

In the main this paper has been critical. It is wrong to adopt such views if they fail to acknowledge past achievements or to offer some constructive approaches to the completion of the programme.–

The achievement of impressive reductions in air pollution is much to the credit of those local authorities which have striven to achieve a great deal for residents in their own and adjacent areas. They have created foundations for the fulfilment of the national domestic smoke control programme.

What is now needed is a concerted effort to complete such a sensible domestic smoke control programme. Resource-conscious local authorities will require inducement to re-instate former, or create new, programmes and there will need to be a reversal of the financial advice which has led to the massive retrenchment in this field. Provision for smoke control grants will not be sufficient and assistance towards staff costs will have

to be provided. Apart from the need to complete the smoke control programme there is, in the immediate future, justification in the assistance which would accrue to the ailing construction and appliance supply industries. There would be the added advantages of assistance to the conservation of fuel and the economies consequent upon reduced air pollution.

The intention of the Beaver Committee was to achieve substantial reduction in air pollution in 20 years and the aim ought now to be to complete enough smoke control orders to give effective pollution control over the vast majority of dwelling houses whether these are in former black areas or not. It is neither practicable or necessary to cover the whole of the country with smoke control orders but, if pollution is to be reduced to the lowest practicable limit, the many areas which, up to now, have been ignored would have to be included.

Other elements must also be tackled and some of these are fundamental. One of the major causes of difficulty in the past has been the absence of a realistic fuel policy and it is time that a commitment was made in this direction. Nationally we are in a position where decisions should be made quickly. In twenty five years natural gas and North Sea oil are likely to be approaching exhaustion. In view of the time element in making long term provision the sooner a fuel policy having regard to the need to control pollution is worked out the better. Essential concomitants of a fuel policy are energy conservation and pollution control programmes and, in connection with the latter point due regard should be had of the need to reduce the sulphur content of fuel. As a start the policy with regard to the availability of grant aid for thermal insulation should be reversed.

In the meantime there are other steps which should be taken. It is desirable that the effectiveness of existing smoke control orders should be improved. The sale of bagged bituminous coal from shops in smoke control areas should be immediately prohibited. It is known that the Solid Fuel trade is itself anxious to eliminate those trade practices which allow coal to be sold in smoke control areas. "Even if the programme is brought to a temporary halt the local authorities must not let slip what has been achieved by relaxing their care, and allowing merchants to deliver and residents to burn bituminous coal in smoke control areas. This is a slippery slope that might be very difficult to climb again. The Federation co-operating with the Fuel Distributive Trade through the Approved Coal Merchants Scheme is desirous of stopping this practice, and has offered its support to local authorities."(20)

While the right of magistrates to fix the level of fines in accordance with the facts as they see them is respected, it is important that they should adopt a realistic attitude to offences which lead to pollution. Those Departments dealing with pensioners must recognise that there can be additional costs in complying with smoke control orders and the financial assistance through supplementary benefit should be such as to enable the elderly to have adequate heating without breaking a Smoke Control Order.

One fact which emerges from surveys for new Smoke Control Orders is that a substantial number of dwellings have been converted by their owners to

smokeless heating. This beneficial development, should be encouraged by reducing the value added tax on such appliances and their installation.

Public expectation in respect of pollution is rising. Cleaner air is now regarded as highly desirable by increasing numbers of people. There is now need for the firmest Ministerial direction firstly to laggard local authorities in respect of the need to complete a satisfactory domestic smoke control programme and, secondly, to planning authorities to emphasise again the need to look with the greatest care at developments likely to produce air pollution which will affect dwellings, existing or projected. This might include restrictions on developments of housing sites if the resulting dwellings would be polluted by adjoining industry.

CONCLUSION

The Beaver Committee saw the need to control all forms of smoke and regarded the role of domestic smoke control as most important. They foresaw cost and effort being involved and hoped for a national and continuous effort. Its hopes have been partially realised and might have been realised more had greater pressure been applied, a higher priority assigned and more resources made available.

Twenty years of effort have been well rewarded but there is some way to go to reach the target and the steps which should be taken are well known. Polluted air is not necessary. Clean air is expensive but is cheaper than polluted air.

REFERENCES

(1) Beaver Committee - Final Report 1954 Cmd 9327
(2) Beaver Committee - Interim Report 1953 Cmd 9011
(3) Clean Air Act 1956 (4 & 5 Elz 2 Ch 52)
(4) Clean Air Act 1968 (68 Elz 2 Ch 62)
(5) Health & Safety at Work etc., Act 1974 (E2 Ch 37)
(6) Control of Pollution Act 1974 (74 Eliz 2 Ch 60)
(7) "Clean Air" Summer 1977 p.16
(8) Annual Report 1976 City of Manchester. Environmental Health Dept.,
(9) Twenty Year Review. Manchester Area Council for Clean Air & Noise Control.
(10) C.M.Wood "Clean Air" Spring 1973
(11) "Clean Air Today" p 19 D.O.E. 1974
(12) "Controlling Pollution" pollution paper No 4 p 4 C.A.R. Crossland.
(13) "Acid Rain" "Observer" 10/7/77
(14) Circular 131/74 September 1974
(15) Memorandum on Smoke Control Areas 1956
(16) Circular 54/76 Department of Environment May 1976
(17) Circular 171/74 Department of Environment December 1974
(18) Circular 120/176 Department of Environment December 1976
(19) Cmd 6393 February 1974
(20) Annual Report Solid Smokeless Fuels Federation 1976/7

NATIONAL SOCIETY FOR CLEAN AIR

44th CLEAN AIR CONFERENCE

SEPTEMBER 19 - 22, 1977

HARROGATE

WHAT HAS BEEN ACHIEVED AND WHAT REMAINS TO BE DONE - IN INDUSTRY

C.J.O. Moorhouse
Group Environmental Affairs Adviser
The Rio Tinto-Zinc Corporation Ltd.

136 North Street
Brighton BN1 1RG
England

INTRODUCTION

A great deal has been accomplished by industry in recent years to abate air pollution, not only in the UK but in other parts of the Western World such as North America, West Europe and elsewhere. Unfortunately, the general public does not appear to be properly aware of the positive efforts made by industry. The natural tendency is to believe the bad things. Of course, mistakes have been made but I would say any errors of commission have generally been due to ignorance rather than malice aforethought. All of us are constantly learning. Until recently, I suspect not many had any real knowledge of the full ramifications of lead in the environment, whether it be lead in petrol, the uptake of lead by flora and fauna, or the emissions of lead and other particulates from a primary smelter. The incidents of past years and the ensuing general debate have taught us all so much, and helped to ensure that the necessary steps are being taken both to protect the workforce and the general environment.

Industry as a whole has been subject, particularly in the past ten years or so, to growing pressures to put its own house in order following the upsurge in public interest and concern. This in turn has led to a great deal of domestic and international legislation and regulations which are now being implemented and enforced. These measures have generally been preceded by vigorous debate, which initially was dominated by the environmentalists, since to start with industry was somewhat sluggish in reacting and responding to this new challenge. A better balance has been struck between the two sides with the improved presentation by industry of technical information.

To cope with these issues and assist management to identify their own environmental problems, many corporations now employ specialists with specific environmental knowledge and experience. Indeed, many large international companies with world-wide interests have scores and even hundreds of staff engaged in this area of various disciplines, mechanical engineers, chemists, biologists and others. However, management continues to take the actual responsibility for operations of which the environment, though vital, is after all but a part.

Environmental control costs these days form a substantial proportion of capital, maintenance and operating expenditures, sometimes amounting to 10% - 15% of the total. It has been reported that one leading multinational company spends no less than 500 million dollars a year on environmental control. The international aluminium smelting industry has stated that the cost of fluoride emission control equipment in 1974 ranged from 2% to almost 11% additional investment.

WHAT HAS BEEN ACHIEVED

Most of us here were only too familiar with the fogs and smogs in urban areas which happily to the young of today are practically a thing of the past. This Society and its predecessors, The National Smoke Abatement Society and The Coal Smoke Abatement Society, have played a major role in

helping to combat the high level of particulates and sulphurous emissions throughout Britain.

But it was the damp, grimy, thoroughly unpleasant and protracted London smog of 1952 which proved the catalyst to action. Widespread public concern about the smog and the 4000 extra deaths which had occurred during it, led to the appointment of a committee under Sir Hugh Beaver. The committee's report confirmed that smoke, grit and dust were major hazards which could and should be controlled, and recommended new legislation to replace the existing inadequate local and national provisions. The committee laid special emphasis on the need for general domestic smoke control.

According to the committee's interim report more than half of the smoke came from industrial sources including the railways but, for each ton of coal burned, domestic chimneys produced twice as much smoke as industry. Nearly all the grit and dust came from industrial sources including power stations and railways. Sulphur dioxide was discharged in smoke whenever coal, coke or oil was burned, whether in industrial furnaces or in domestic grates.

The Beaver Report led to the Clean Air Act 1956, later supplemented by the Clean Air Act 1968, giving local authorities considerable powers to require improvements from industry.

The following is a summary of the provisions (reference 2):

(i) New plant must be capable of sustaining smokeless operation;
(ii) Proposals to install new furnaces must be notified to the local authority;
(iii) There are permitted periods for dark and black smoke emissions from chimneys;
(iv) Dark smoke emission from bonfires etc. on industrial or trade premises is, subject to exemptions, prohibited;
(v) Smoke other than from a chimney may, if it causes a nuisance, be regarded as a statutory nuisance under the Public Health Act 1936;
(vi) Heights of chimneys to serve furnaces are subject to prior approval by the local authority; and
(vii) Emission of grit and dust from furnaces is controlled.

The legislation has had important effects. In 1956, handfiring of coal into furnaces was the rule rather than the exception and smoke emission, even when a furnace was skilfully fired, was inevitable. Grit and dust emission was considerable especially when fires had to be raked and clinker and ash removed. The continual opening of the furnace door to add fresh coal resulted in still heavier smoke emission, as well as a waste of fuel.

The Act provided the spur necessary towards mechanical firing of coal or conversion of furnaces to burn gas or oil. These changes brought about improved conditions in boiler-houses and reductions in emission of smoke and grit.

A further control of smoke emission from industrial sources was that introduced by smoke control orders. Whilst applying primarily to domestic premises the inclusion of industrial premises in a smoke control area had the dual effect of ensuring either that properly maintained and operated mechanical stokers or oil burners were fitted to furnaces or that furnaces were converted to burn an authorised fuel such as coke or anthracite.

The community has benefited accordingly as can strikingly be seen in the industrialised cities of the North and the Midlands, particularly the Potteries. Once a notoriously polluted industrial centre, Sheffield is today establishing itself as a conference and tourist centre. In parts of the city there has been a decrease of about 90% in average smoke concentrations. Salford is another city where there have been striking improvements in air quality. Since smoke control was introduced in 1960, average smoke concentrations have been reduced by something like 90%.

Since the Clean Air Act 1956 there has also been a reduction in ground level concentrations of sulphur dioxide and no doubt my fellow author, Mr. Foskett, will be dealing with the significant contribution made by control of domestic pollution.

The Act imposed on local authorities the duty to ensure that new chimneys were tall enough to limit, as far as possible, risk to health and to help preserve amenity. The memorandum on chimney heights circulated to local authorities has been a benchmark for many years. Between 1961 and 1974 the national total of emissions of sulphur dioxide by weight did not alter substantially since there was a decrease from low level sources, such as private houses, to compensate for an increase from high level sources such as power stations and factory chimneys. None the less, the average urban annual ground level concentration was reduced by nearly half.

Concentrations of sulphur dioxide, unlike those of smoke, are highest in London. This is probably due to the quantities of sulphur-containing fuel used to heat the vast number of offices and business premises in the capital. Local powers, following the initiative of a distinguished former President of this Society, Mr. Stanley Cohen, apply in the square mile of the City of London, which limit the sulphur content of fuel burned in new installations.

THE ALKALI ACT

The general responsibility for controlling industry's pollution of the atmosphere rests with local authorities by virtue of their various powers and duties under the Clean Air and Public Health Acts and the Control of Pollution Act. But there is also a quite separate set of controls for a relatively small number of important industrial processes which present special problems, the emissions from which are potentially dangerous or difficult to control and which require expert attention. These are the "scheduled" processes covered by the Alkali Act, and now by the Health and Safety at Work etc. Act 1974, and controlled by the appropriate Central Inspectorate.

There are about 300,000 industrial and commercial premises in the UK; some 30,000 have emissions which are significant and require particular attention or surveillance. Of the 30,000 about 2000 works (involving over 3000 processes) are controlled by the Alkali Inspectorate and account for three-quarters of the fuel used in all premises. (Reference 1)

There are some 60 different kinds of registered processes under the control of the Inspectorate. They include processes in the chemical, metal, fuel, cement, ceramic and allied industries.

The Inspectorate requires the best practicable means* to be used to prevent or reduce emissions, and to render what is emitted "harmless and inoffensive". Codes of Practice based on years of experience and know-how are in the process of being adopted for individual industries following discussion with representatives of the particular industry concerned. The Inspectorate also advises on adequacy of maintenance, control and supervision, and is very much concerned with the preservation of environmental amenity around the works which it supervises.

In industry we very much welcome the close contact maintained by Environmental Health Departments with the central inspectorates often (as at Avonmouth) by organising environmental "watchdog" committees, comprising all interested parties, which review monitoring data, interpret it for the general public and suggest remedial actions if necessary.

Best practicable means (bpm) is a philosophy that those of us who work in industry consider makes better sense than having to conform to uniform air emission standards and we were, therefore, pleased when the Royal Commission on Environmental Pollution endorsed the concept and proposed that it should be extended to cover industrial pollution affecting water and land as well as air. It was also reassuring to read in the Department of the Environment Pollution Paper No. 11 "Environmental standards: A description of United Kingdom practice", published earlier this year, that there continues to be an understanding of the advantages of a system such as ours which allows for flexibility in order to meet local conditions.

---

* <u>Alkali Inspectorate Criteria for Presumptive Limits</u>

I No emission can be tolerated which constitutes a demonstrable health hazard, either short or long-term.

II Emissions, in terms of both concentrations and mass, must be reduced to the lowest practicable amount.

III Having secured the minimum practicable emission, the height of discharge must be arranged so that the residual emission is rendered harmless and inoffensive. (For highly toxic metals, the contribution of each source to the existing background concentration shall not exceed one-fortieth of the Threshold Limit Value for a factory atmosphere, on a three-minute mean basis. In deciding on the most important parameter, the effects on vegetation, animals and amenity are also considered.)

LEAD

In the lead industry we have learned, sometimes the hard way, of the necessity to limit still further lead emissions not only from chimney stacks but also near ground level. The industry is much better aware than it used to be of the need to ensure personal cleanliness within a plant. Changing room facilities are now regarded as essential so that workers do not take lead home with them and thereby risk contaminating other members of their households. Monitoring is accepted as vital, both for lead-in-air and blood-lead levels, and the industry is working to hygiene standards established by Government.

ALUMINIUM INDUSTRY TAKES GOOD CARE

Let's take a look in rather more detail at another industry with which I am fairly familiar, the aluminium industry, where control techniques have made great advances in recent years.

The operation of reduction cells (of which there may be 300 on a typical 100,000 ton/year plant) produces particulate and gaseous fluorides which are the main potential pollutants associated with the industry.

The main concern with these emissions is their effect on vegetation and farming.

The aluminium industry has developed highly effective systems to limit the emissions of fluorides and monitor their effect on the environment, to standards agreed with the Alkali Inspectorate for preventing economic loss to the farming community.

Prevention of escape of gases and particulate from the reduction cells is effected as far as is reasonably practicable by hooding the cells and exhausting the contained fluorides to a scrubbing system to ensure removal of fluorides to a safe level.

Collection efficiencies of up to 95% and purification efficiencies of 95% plus are possible on the most modern plants.

Various combinations of control equipment such as wet scrubbers and dry scrubbers are used for purification, often followed by high stacks for final dispersion. Even higher scrubbing efficiencies using dry scrubbers are making the need for tall stacks unnecessary.

The small percentage of gases escaping from the hooding and a smaller percentage of the particulate are entrained with large volumes of ventilation air passing through the building and are discharged as highly diluted gases at roof level. The effect from these tends to be of a local nature.

To observe closely the effectiveness of these measures the controls are supported by regular ambient air monitoring on surrounding land, herbage sampling, regular checks on cattle and other animals grazing in the

vicinity, and examination of local susceptible vegetation. Outside veterinary and botany consultants are used to help distinguish between any fluoride effects and other non-associated problems, such as the effect of salt spray on vegetation.

Many companies have found it convenient to own and farm the surrounding land themselves. In at least one location in the UK, the land is managed by a farm manager especially appointed by the company. Cattle are selectively moved from field to field to ensure their fluoride intake levels never exceed prescribed levels, and by these means they profitably maintain the best dairy herd locally, producing milk yields significantly above that of most commercial dairy herds.

Operating this way permits meaningful co-operation and discussions between the company environmental control groups, the company farm manager, outside consultants and local interested parties such as local farmers and their representative bodies, the Nature Conservancy, and others.

THE MOTOR VEHICLE

Motor vehicle emissions are by no means a totally new problem: the Beaver Committee addressed itself to this issue during the 1950's when there were far fewer vehicles on the road than today. Though traffic produces a variety of pollutants, and some unpleasant smells, it is not certain that any of its effects are by themselves dangerous to health. Even the highest concentrations of carbon monoxide found in cities do not usually approach danger levels - the individual is in more danger from smoking a cigarette than from walking down a busy street - but they do add to the level of pollution in the urban atmosphere. The real problem here is the need for adequate ventilation in tunnels and enclosed car parks.

Regulations have been introduced in this country limiting the quantities of carbon monoxide and hydrocarbons which new designs of motor vehicles may emit into the atmosphere. There is no evidence that hydrocarbons produced by motor vehicles are necessarily significant hazards to health. But their unpleasant effects, like those of dirty smoke from badly maintained diesel engines, are sufficiently undesirable for action to have been taken to regulate them. (Whether the regulations are adequately enforced is of course another matter.) The standards now in operation involve substantial reductions in the emission of carbon monoxide and hydrocarbons as compared to a few years ago, though they apply only to new vehicles because of the very considerable cost and technical difficulties presented by attempts to adapt existing engines.

Lead in petrol has been the subject of much controversy. No one is of course arguing that lead from the exhaust of a motor vehicle is healthy, but there is I believe a better appreciation today of the pros and cons of its use, and its value in raising the octane level of motor gasoline and in turn its bearing on the efficiency of the engine and energy conservation.

In some senses it is ironic that the energy crisis should have hit us at the very moment when also we have become so aware of environmental problems, but people are now beginning to realise that a balance needs to be struck to secure optimum results. After all, there may be little sense in reducing the lead content of gasoline too far, if the consequence of this is higher emissions of other exhaust products such as carbon monoxide, nitrogen oxides and hydrocarbons due in large measure to higher fuel consumption.

The UK Government's stated policy is to keep total lead emissions from traffic from rising as a precautionary measure. This is being done by a series of reductions of lead in petrol down to in due course a level of 0.4 grammes of lead per litre. (The present UK limit is 0.5 grammes per litre.)

WHAT REMAINS TO BE DONE

Looking ahead, what are some of the outstanding problems that continue to face industry?

We have the problems already identified which may call for further action, and there are the unknowns and the unexpected. Among the unexpected was the tragedy at Seveso in Italy now over a year ago when an explosion at a chemical plant spewed several pounds of a deadly chemical called dioxin on Seveso and nearby towns and farmland. Dogs, rabbits, and cows ate the chemical and died. More than a hundred people, mainly children, developed an ugly skin rash. Fifteen days after the accident, more than 700 families were evacuated from their homes. Scores of businesses were closed.

Then, though outside the strict scope of this paper, there was the recent blow-out in the North Sea which led to the sea in the vicinity of the oil rig being contaminated with an oil slick and to the fear that if oil dispersants were used they would kill off marine life.

Or, yet again, there was the chemical explosion at Flixborough which had its toxic side effects in addition to the tragic consequences for so many.

There may be a certain inevitability about incidents and accidents of this sort, but I do believe we in industry need to do more to try to anticipate the unexpected and be better prepared to cope with the emergency when it does arise. It does seem to me that we need to adopt a more systematic approach within industry to probe more closely what are the potential risk areas and to advise management accordingly.

Naturally, in trying to identify our own problems, both short and longer term, we are very much guided by governmental authorities, both national and international, and the view they take of particular problem areas. Increasingly, in this connection, we can expect to be still further influenced by the EEC and at a further remove by such organisations as the United Nations Environment Programme. Earlier this year the EEC published a report, "State of the environment: First report", which includes a

chapter on air pollution which is bound to have an influence on our approach in this country. This chapter highlights four pollutants chosen for priority investigation under the EEC Action Programme adopted in November 1973, namely, lead and its compounds, sulphur compounds, nitrogen oxides and carbon monoxide. The Programme will lead to further EEC draft directives and regulations which are daily becoming more and more part of our life and all of us are increasingly being drawn into the debates on individual topics before final decisions are taken.

Let me discuss just a very few of the problems ahead of us:
There is the issue of long-range transport of sulphur dioxide and of acidic rain.

The Scandinavians in particular have expressed great concern that the increasing acidification of inland waters was causing the observed fall in fish populations and was also reducing forestry production. In their opinion, the sources of acid precipitation were sulphur dioxide emissions from the heavily industrialised countries of north-west Europe, particularly those from the UK. This latter view was based on the assumption that south-west winds prevailed and that the UK policy of making major industrial emissions from tall chimneys (the "tall-stack" policy) to reduce nearby surface concentration - which affects about half the total UK emission - is particularly effective in encouraging the transport of pollutants over long distances. (Reference 12)

Monitoring has been carried out under an OECD programme in Western Europe for the past 5 years with the aim of determining the relative importance of local and distant sources of sulphur compounds within European countries, special attention being paid to the question of precipitation acidity. The results that have emerged allow some generalisations to be made but do not as yet provide a definitive answer to the questions that have been raised.

To quote from the Nature-Times News Service for July 1977: "The 11 countries participating in the study put roughly nine million tonnes of sulphur into the atmosphere every year and sulphur compounds return to the Earth at the rate of, on average, one or two grams a square metre a year. All countries obviously receive back on their own territory a sizeable fraction of what they put up, but some countries, notably Denmark and the United Kingdom, export much more sulphur than they import. Others, notably Austria, Finland, Norway, Sweden and Switzerland, receive considerably more from other countries than they export."

One cannot hope to do justice to the content of such an important study as this in the course of a few brief allusions, so let me merely say that I believe the findings are likely to increase the pressures for further desulphurisation and for other measures to abate pollution by sulphur dioxide. Some people may also be inclined to question our high-stack policy but before any remedial measures are contemplated, let alone taken, there is clearly here a fruitful field for cost-benefit analysis to determine the most appropriate solutions to these contentious problems.

A draft EEC Fuel-oil directive, if accepted, may require the UK to designate Special Protection Zones and to reduce the sulphur content of fuel-oil burned within such a zone even if the pollution is primarily due to the combustion of other fuels; for example, domestic coal in the North West of England. It would be likely to lead in some places to increased industrial costs for minor improvements in air quality. I therefore think it is encouraging that our Government has said it will oppose this proposal on the grounds that it would not be a cost-effective way of reducing pollution and that member states should be free to take measures to control pollution appropriate to local circumstances.

Side by side with the draft Fuel-oil directive is an EEC proposal for a Health Protection Standards directive which specifies ground-level concentrations of sulphur dioxide and suspended particulates, and requires member states to use appropriate measures to reach these levels by 1982, though up to 1987 certain higher levels may be exceeded briefly under adverse meteorological conditions. In the UK, the measures might include domestic smoke control and probably some reduction of the sulphur content of fuels where relevant.

HEAVY METALS

It is evident, too, both from our own experience and from EEC thinking that heavy metals will continue to call for close attention. This is reflected in proposals to set EEC-wide air quality standards for lead (and also for fluorides). At the risk of repeating myself, many of us in industry feel it would make better sense as the Department of the Environment recently put it in their Pollution Paper No. 11" .... to attack emission sources from which an acceptable general air quality follows. Experience suggests that this provides adequate safety without imposing undue burdens on industry". However, as is said in this Paper, the Government is at present considering the recommendations of the Royal Commission on Environmental Pollution for a system of air quality guidelines for major pollutants. These guidelines would not be legally enforceable, but would provide objectives against which local and national air pollution control policies could be judged.

ON THE ROADS

The continuing increase in traffic (it is estimated that 70% of families may be car owners by 1990, compared with 55% today) suggests that the pollution problems posed by motor vehicles will be a problem for the foreseeable future. The possibility of developing pollution-free transport is enticing, but the prospects either of making the internal combustion engine anywhere near pollution-free or of replacing it generally with electric or other power units still seem distant, despite continuing advances in these fields.

CHLOROFLUOROCARBONS (CFCs) - STRATOSPHERIC OZONE

There are also even wider questions which can have far-reaching repercussions on local activities. Consider the current debate about the alleged depletion of the so-called ozone layer due to the release into the atmosphere of chlorofluorocarbons used in aerosol sprays, and to a lesser extent in refrigeration and air-conditioning units. In the United States there are moves afoot to ban the use of CFCs and at a stroke both manufacturers and consumers may be deprived of a market and of a convenience product, whether justified or not. This situation has arisen following assertions that man-made chemicals such as these can have the effect of reducing ozone concentrations in the upper atmosphere and consequently allowing greater ultra-violet (UV) radiation to reach the earth. However, others - including I venture to say the UK Government - would argue that the problem is not such as to justify immediate action and that much more international research is needed before we can speak with any certainty about this extremely complex issue.

In recent publications, Professor Scorer has, as so often, reached the heart of the matter. On the one hand, it would appear that, in some parts of the world at least, there is a higher incidence of skin cancer. On the other hand, particularly since the Second World War, there has been a noticeable change in the life style of people who have been exposing themselves very much more to the sun's rays than used to be the case. Furthermore, the medical approach has become more sophisticated, and more cases are being recorded.

Theoretical predictions using mathematical models of chemical reactions in the upper atmosphere have their distinct limitations. It has been suggested that a maximum depletion of about 8% in the "ozone layer" could occur in about 100 years' time (which may be uncertain by a factor of three) causing an increase of about 16% in UV radiation reaching the ground. One has to set that prediction against the apparent fact that the concentration of ozone in the upper atmosphere has if anything been showing a slight upward trend in the past 40/50 years. Furthermore, the ozone concentration varies substantially from summer to winter, being from 25% higher in the summer and therefore lower in winter. Furthermore again, it varies from the equator to the pole, being three times as high at the pole, not to mention that it may vary from day to day by 10 - 15%. At the same time I would not myself be inclined to attach over-much importance even to these particular figures. They should merely be taken as a rough indication of the changes that may be taking place.

Environmentalists would argue that if there is any possibility at all of harm being caused, the use of chlorofluorocarbons as aerosol propellants should be banned. This argument could, of course, apply to virtually any substance since to prove harmlessness in a medical sense is almost impossible.

Pending a firm decision one way or the other, industry is continuing with its research programme in close co-operation with government and stands ready to provide as much scientific information as it can to help the authorities to reach a well-considered decision.

ASBESTOS

The dangers of asbestos dust have been brought home to us in recent years. The Advisory Committee on Asbestos meeting under the Chairman of the Health and Safety Commission himself was at the time of writing reviewing all the health aspects of exposure to asbestos dust with a view to making recommendations.

One tends to think, first of all, of exposure to asbestos in the workplace, but there are also several other sources of atmospheric asbestos exposure such as emissions from factories, emissions from waste disposal, emissions from building and demolition sites, release of fibres from brake linings and exposure in the home from D.I.Y. work.

Asbestos is of course valued especially for its fire protection, but this advantage now has to be weighed against any health risks involved, and increasingly users will have to strike a balance between the two.

THE WEALTH OF KNOW-HOW IN INDUSTRY

Industry's ability to contribute to the solution of environmental problems is far greater than most seem to appreciate. It is, I believe, a considerable misfortune that government and the academic world do not look to us far more to help solve some of the outstanding problems. Our scientists and engineers have a wealth of know-how and experience, often unique in the world, and I personally hope that industry will be given wider opportunities to make a contribution to the solutions of the very big problems that continue to face us.

ACKNOWLEDGEMENT

The author wishes to express his appreciation to the Department of the Environment for permission to base part of his paper on material prepared for the Clean Air Council of which he is a member and Chairman of the Standing Review and Information Committee; he is also particularly indebted to the Manchester Area Council for Clean Air and Noise Control for allowing him to quote paragraphs dealing with the control of industrial pollution in their "Twenty Years Review of Air Pollution Control in the Area of the Council", 1976. The content of this paper and the views expressed herein are, however, solely the responsibility of the author.

REFERENCES AND BIBLIOGRAPHY

1. "Constraints and Procedures for Discharge to the Atmosphere", Edgar Briggs, BP Oil Ltd. EUROCHEM Conference, Birmingham, June 1977.

2. "20 Years of Air Pollution Control", Report by Manchester Area Council, 1976.

3. "Fluoride Emissions Control: Costs for new aluminium reduction plants". Report by International Primary Aluminium Institute Environmental Committee. April 1975.

4. "Understanding Occupational Exposure to Fluoride". Special issue, Journal of Occupational Medicine (US), January 1977.

5. "Environmental Aspects of the Aluminium Industry - an overview". Report on United Nations Environment Programme Seminar, Paris, October 1975. Published by UNEP Industry Programme, May 1977.

6. "Costs of reducing SO_2 emissions and improving effluent water quality from refineries". CONCAWE Report No. 5/77. March 1977.

7. "The Fight for Clean Air - a Report by the Clean Air Council". In preparation.

8. "State of the environment: First report". Published by EEC, Brussels. 1977.

9. "British Industry and Pollution Control in the EEC". E.F. Thairs.

10. "Health and Safety - Industrial Air Pollution 1975". Annual Report by Chief Inspector, HM Alkali and Clean Air Inspectorate.

11. "Environmental Standards: A Description of United Kingdom Practice". Department of the Environment Pollution Paper No. 11, HMSO 1977.

12. "Sulphur Deposit Account". R.A. Barnes. Nature, Volume 268, 14 July 1977.

13. "Chlorofluorocarbons and their Effect on Stratospheric Ozone." Department of the Environment Pollution Paper No. 5. HMSO 1976.

14. "The danger of environmental jitters". Professor R.S. Scorer. The New Scientist, 16 June 1975.

NATIONAL SOCIETY FOR CLEAN AIR

44th CLEAN AIR CONFERENCE

SEPTEMBER 19 - 22, 1977

HARROGATE

THE ENVIRONMENTAL PROGRAMME OF THE EEC AND ITS POSSIBLE EFFECTS ON EXISTING CLEAN AIR LEGISLATION

A.J. Fairclough
Central Unit on Environmental Pollution,
Department of the Environment

136 North Street
Brighton BN1 1RG
England

1. I have been asked to address the conference on the environmental programme of the EEC and its possible effects on existing clean air legislation.

2. The European Communities are of course much in the news these days with negotiations - over prices, over foreign policy, over economic issues, the common agricultural policy, herring fishing and so forth - all part and parcel of our regular diet as we open our newspapers in the mornings. A proposal by the Commission on this. A meeting of the Council on that. An opinion by the Parliament on the other. Speeches by many Ministers of all nine Member countries, sometimes on their own behalf and sometimes, as Presidency, on behalf of the whole Community. Speeches by Commissioners. Summits here. Official group meetings there. All followed by numerous communiques, declarations, resolutions, directives, opinions etc.. In addition to all this there is of course also continuous action in our own Parliament through Scrutiny Committees in both the House of Commons and the House of Lords, concerned to keep an eye on the progress of Community measures - their reasonableness, their justification and their impact on British law and British policies.

3. I can well understand people getting confused about all this. And I could equally well understand those concerned with air pollution matters and with existing British legislation in this field if they took the line, as regards Community activities that, although they are no doubt necessary on a wide range of matters, it is not at all clear what a Common Market has got to do with the quality of air in Britain.

4. The connection is not immediately obvious and I thought therefore that, before going on to discuss the possible effects on existing clean air legislation of the EEC's environmental programme, I would take a little time to spell out why there is a connection, how the EEC works and what this country's broad policy stand has been in relation to environmental matters. If we can get these broader issues into focus it may I believe help in understanding the possible implications of the environmental programme for air pollution legislation in this country.

5. Let me then start with the obvious challenge - why has a Common Market got anything at all to do with our air quality legislation? It is of course a fact that the Treaty of Rome is essentially concerned with the establishment of the Common Market and with the laying down of rules and procedures by which it shall operate. And a large part of Community action is concerned with precisely this.

6. However there is and always has been a political motivation behind the Community and this manifests itself in all sorts of ways. One of them is that Community action is taken in a wide range of areas that are only indirectly connected with the functioning of the Common Market. Community action in such areas has of course a somewhat different character from action which flows from specific Treaty commitments. It is more "optional", to be considered on a case by case basis on its merit. And in that sense such action (and the related negotiations) are much more akin to what goes on in other international fora. The environmental area is one area of this

kind.

7. But why should it be? If one thinks for example of pollution control requirements as applied to motor vehicles there is plainly a case for uniform requirements throughout the Community; if each Member country had quite different requirements this would be bound to have an impact on the operation of the Common Market. Yet what about our smoke control legislation? Surely this is an entirely domestic matter having no possible impact on other Member countries or on the operation of the Common Market?

8. The fact of the matter is of course that the picture is not a simple or straightforward one. Certain provisions touching on air pollution control can be of Community wide relevance - and may indeed be of much wider international concern. Others are purely domestic. Let me then go on to describe what has actually been done to date in the Community and consider what its possible implications are for legislation in this country.

9. The simple point to make in this context is that, although there is no explicit provision in the Treaty of Rome requiring action by the Community in the environmental field, the fact of the matter is that the Community has adopted [1] (and reaffirmed [2]) a wide ranging Environmental Action Programme spelling out aims, objectives etc. and indicating in broad terms what action in which fields the Community plans to take in order to, and I quote:-

> "Improve the setting and quality of life and the surroundings and living conditions of the peoples of the community"

by procuring for man "an environment providing the best conditions of life" whilst reconciling this with the "need to preserve the natural environment".

10. This programme, which is divided into two broad areas - measures to reduce pollution and nuisances; and action to improve the environment - was approved by the Council of Ministers in November 1973; and reaffirmed and developed (with a new section concerned with the non-damaging use and rational management of land, the environment and natural resources) in May 1977. And it has been throughout - and remains - the object of a very active programme of implementation on the basis of directives and other measures proposed by the Environmental Protection Service of the European Commission.

11. Perhaps this is the point at which to pause briefly and make plain for any who may not be familiar with the Brussels scene, the distinction between the Commission and the Council. The Commission consists of 13 members appointed by agreement of the Governments of the Member States (2 from the UK, France, Germany and Italy; one from each of the others) but sworn to exercise complete independence in the discharge of their duties. They are supported by a staff of some 7,500 people of all Community nationalities. The Commission is charged with ensuring the proper functioning and development of the Common Market. To this end it is accorded certain powers of decision in its own right both by the Treaty

and by actions of the Council of Ministers. In relation to new legislation giving effect to and developing the principles and provisions of the Treaty, the function of the Commission is to make proposals to the Council of Ministers. It is the Council which legislates. The role of the European Parliament is to offer a non-mandatory opinion on the Commission's proposals. The Environment Action Programme provides a framework within which the Commission prepares the proposals but, subject to this, and the requirement to cite specific provisions of the Treaty in justification, the Commission has a pretty free hand as to how, when and in what form it presents its proposals. And the Commission itself - and individual members of its staff - jealously guard this right of initiative.

12. Once a proposal is transmitted by the Commission to the Council of Ministers for decision, it is published. It is then painstakingly discussed between representatives of all nine Member countries (with Commission representatives in attendance) in what is essentially a negotiation process. This negotiation proceeds until a suitably amended version is arrived at, which can be adopted unanimously by the Council of Ministers - and all decisions in this forum on matters of importance are in practice taken by unanimity.

13. In other words, to put it succinctly, the Commission proposes and the Council disposes. This - and the fact of the unanimity rule - are important features of procedures in the Community. They mean, in effect, that, although we are committed by the Treaty and, in the environment field, have subscribed to the general approach laid down in the approval programme, no individual measure requiring Council approval can be passed into effect unless we and all the other member countries consent to it. This is an important safeguard and of course it means, as one of its consequences, that a good deal of time is taken, within the Working Groups operating under the auspices of the Council, by the slow and often tedious process of amending and altering Commission proposals to the point at which a formula can be arrived at which is politically acceptable to all nine Member countries with their very different backgrounds and problems.

14. That then is the general framework. Let us now have a look at how it all works out in practice and consider in particular the United Kindom's approach to the Community's environment programme.

15. The fundamental approach to environmental protection laid down in the Community's environment programme is by the establishment of quality objectives for all significant pollutants, based upon criteria studies. To be sure there is a lot more to the programme than this; and there are particular types of problems for which different approaches are appropriate and are envisaged. But there is no doubt about the quality objectives approach in that part of the environment programme concerned with the reduction of pollution and nuisances.

16. Part I of the programme sets out the objectives and principles of a community environment policy; and a series of tasks for the Community are laid down.
The first two are as follows:-

"1. The laying down of scientific criteria for the degree of harm of the principal forms of air and water pollution and for noise. This action must go hand in hand with the standardisation or alignment of the methods and instruments used in measuring these pollutants and nuisances. In the laying down of criteria priority will be given to the following pollutants: lead and lead compounds, organic halogen compounds, sulphur compounds and particles in suspension, nitrogen oxides, carbon monoxide, mercury, phenols and hydrocarbons.

2. The definition on the basis of a common methodology, of parameters and the decision-taking process in connection with the laying down of quality objectives."

The remaining tasks defined are to do with information exchange and estimates of costs.

17. At a later stage in the same chapter of the programme where specific action is being spelled out we find the following:-

> "2. The preparation of a list of quality objectives determining the various requirements an environment must meet bearing in mind its allotted purpose. Community action will also be oriented towards the search for long term quality criteria with which the various parts of the Community environment will have to comply."

18. It is perhaps worth adding that the environment programme is very precise about what it means when it stresses scientific criteria and quality objectives. Both terms are defined as follows:-

> "The term 'criterion' signifies the relationship between the exposure of a target to pollution or nuisance, and the risk and/or the magnitude of the adverse or undesirable effect resulting from the exposure in given circumstances".

As to quality objectives, the programme has this to say:-

> "The 'quality objective' of an environment refers to the set of requirements which must be fulfilled at a given time, now or in the future, by a given environment or particular part thereof."

and the definition goes on to stress that in setting objectives both "basic protection levels" and "no effect levels", determined on the basis of scientific criteria as defined, are to be taken into account; and that due allowance should also be made:-

> "for the specific regional conditions, the possible effects on neighbouring regions and the intended use".

19. On standards the programme has the following to say:-

> "Standards are established in order to limit or prevent the exposure of targets and can thus be a means of achieving or approaching quality objectives. The standards are directly

or indirectly addressed to the responsible individuals or bodies and set levels for pollution or nuisance that must not be exceeded in an environment, target, product etc.. They may be established by means of laws, regulations or administrative procedures or by mutual agreement or voluntary acceptance."

The programme then goes on to define the various types of standard, including product standards, emission standards, design standards, operating standards etc.; but also including:-

> "Environmental quality standards which, with legally binding force, prescribe the levels of pollution or nuisance not to be exceeded in a given environment or part thereof".

20. That then is what the programme says. How can one sum it up? I think myself that it is fair to say that the whole approach of the Community's environment programme for the reduction of pollution and nuisances in based upon the establishment of appropriate quality objectives, developed in the light of scientific criteria; and that legally binding standards of various kinds are seen as possible means whereby these objectives can be approached. This is of importance from two points of view, both of which I should like now to discuss - the process by which scientific criteria are established and the United Kingdom's own approach to the Community's environment programme.

21. Plainly the establishment of scientific criteria is - or can be - a complex and difficult matter importing highly scientific or technical considerations in a number of fields. So far as air pollutants are concerned one is plainly interested in health, in climatological and meteorological phenomena, in dispersion and fallout, in interaction with other atmospheric components and so forth. Before scientific criteria which have any sort of reliability can be produced therefore, it is normally necessary to contemplate a fairly long process of consultation and discussion involving experts in the various fields concerned.

22. The United Kingdom has from the outset been insistent upon the importance of a process of evaluation leading to the establishment of criteria <u>before</u> proposals for Community action, based on objectives or standards, are put forward. We have sometimes been critical of the Commission in this regard. Obviously a comparatively small group of officials within the Commission headquarters in Brussels cannot themselves have all the necessary skills available "in house", and the Commission normally consults experts - either individual experts or alternatively expert groups in which experts from each Member country that wishes to participate come together (still as individual experts rather than as representatives of their countries, but with the intention collectively of advising the Commission on the scientific basis for possible action).

23. Our criticism in this area has essentially been that, whether or not this process has taken place, the proposals actually put to the Council sometimes have not been adequately thought out scientifically. This can lead to the Council Environment Working Group having to devote

a great deal of time to technical discussion, as a preliminary to modifying the proposals so as to reflect the scientific basis. It would in our view be far preferable if the fullest possible degree of consensus and certainty on the scientific basis for proposed action could be established before proposals are put to the Council.

24. I think that it is true to say that our arguments in this regard have carried some weight for recently the Commission does appear to have placed much greater stress on full and careful preparation than they did a few years ago. At all events it is a point upon which the United Kingdom has insisted throughout - I recall the late Mr. Crosland making it at the first Council meeting of Environment Ministers in November 1974; and it is one on which I think we shall continue to place considerable emphasis.

25. A second point of importance in the approach laid down in the Community's environment programme is the fact that the central emphasis is placed on environmental quality objectives - to be prepared in the light of and on the basis of established scientific criteria and prior to the laying down of any binding quality standards. This too, as is well known, is a matter to which the United Kingdom attaches particular importance.

26. We recognise, of course, that it is not always possible to wait until scientific knowledge has progressed to the point at which there is a full understanding of dose/effect relationships allowing criteria to be established from which firmly based standards can be derived. Sometimes it is necessary, on grounds of prudence, to set precautionary standards, or guide levels, on a temporary basis. Scientific principles and all relevant and reliable evidence need to be applied in so doing. But it is in no one's interest to pretend that there is a firm scientific base when there is not.

27. Our whole approach - as I scarcely need emphasise to this audience - is a pragmatic one based upon the use of various means as appropriate (and I will come back to the question of means a little later on) to sustain or improve the quality of our environment.[3] Except in relation to product standards (for example, vehicle emissions) where there are international trade implications as well as the consideration that the products may be used in widely differing environmental situations, we do not on the whole favour the use of uniform standards - and this is especially so in relation to uniform emission standards - as a means of achieving satisfactory environmental quality. By 'uniform emission standards' I mean binding standards which set levels for pollutants or nuisances not to be exceeded in emissions, which are the same regardless of the location of the plant and local environmental conditions. In most cases so much depends upon the local circumstances: dispersion, the closeness together of related emission sources, the use to which the particular local environment has to be put etc., that, in the United Kingdom view, it almost ceases to be meaningful (at any rate in terms of sound environmental management) to adopt uniform emission standards as a basic method of control.

28. Some other countries, however (including, let me admit, not only our European partners, but also the United States), take a different view (at any rate in relation to some substances); and the Commission too has tended on occasions to favour uniform emission standards. The arguments advanced for this approach vary. Sometimes it is urged on grounds of competition - ensuring equal impositions on all. This is an argument which the United Kingdom totally rejects in this simplistic form. Certainly it is wrong that industry should be permitted to behave in an environmentally irresponsibly manner, and thereby gain competitive advantage; but it is pointless to impose uniform requirements, implying uniform costs in circumstances where this expenditure leads to no environmental improvement. What can reasonably be accepted by way of industrial emissions will obviously vary from place to place - just as climates, the occurrence of mineral resources, distances between industries and their market and so forth (all of which affect competition) vary widely from place to place.

29. The most persuasive <u>environmental</u> arguments for uniform emission standards are generally based on some variant of the following approach - substance X is known to be toxic or at least highly undesirable; there is major uncertainty about its effects or about the levels that are tolerable; in the circumstances it makes sense to require everybody to limit emissions to the maximum extent reasonably and technically possible.

30. As I said, this is the most environmentally persuasive of the arguments advanced in favour of uniform emission standards. But it fails to take account of dilution and of varying environmental circumstances. And it is an approach which bases itself upon the assumption that substances are toxic, whereas in fact there are strong arguments for the view that it is concentrations that we ought to be worried about. And that therefore the right and proper approach to environmental protection, and the only one which makes economic sense, is one that bases itself on the establishment of environmental quality objectives and then focusses on tailoring individual emission controls in such a way as to ensure, (in the most economical and practicable way) that those objectives are met. This has, of course, to be qualified in relation to substances which can be accumulated biologically. And we must recognise that it may be difficult, where we are dealing with a multiplicity of sources or extreme variability of the diluting medium, to apply this approach in an optimal way. But this is no reason for abandoning it in favour of an unscientific approach which may result in levels of protection which are too low or unnecessarily high.

31. This in brief is the essence of the argument over quality objectives versus uniform emission standards that has been going on for some time within the Community. But it is important to get this disagreement into perspective. It has, in the main, been confined to the appropriate means for controlling discharges into water of a limited number of substances - the "blacklist" substances, i.e. those that are potentially particularly damaging environmentally because they are at once toxic, persistent and bioaccumulatable. This has been dealt with by the Council in a Directive on dangerous substances in the aquatic environment [4] on the basis that a dual approach should be adopted. What this means is that the Directive makes provision for the establishment and monitoring of environmental

quality objectives and for the laying down of uniform emission standards; it is for Member countries to choose which of these two approaches to the control of these substances in the aquatic environment they will adopt.

32. It would be misleading to pretend that this has resolved the difference of view to the satisfaction of everyone concerned. But work is now in hand on the practical development of both approaches and this may well lead to a convergence of views in due course. The point I wish to emphasise is that, as regards those "substances which have a deleterious effect on the aquatic environment, which can, however, be confined to a given area and which depend on the characteristics and location of the water into which they are discharged", the Directive provides for control through a system of quality objectives and emission standards calculated in terms of these quality objectives. The area of agreement is far more extensive than the area of disagreement.

33. In talking about the approach adopted by the Commission in carrying forward work under the environment programme, I have already indicated in broad terms two of the most important points that the United Kingdom has consistently stressed throughout - the need for careful scientific preparation before proposals are put forward and the environmental desirability of an approach to protection based upon quality objectives rather than upon uniform emission standards. There is one other major point that we have equally consistently stressed and that I have already touched on in passing; but I should like to say a few words specifically about it.

34. I have underlined the variability of the environment; and the variability of its capacity to dilute and degrade wastes. There is an equal variability amongst wastes and the nature, scale and geographical spread of their likely polluting effects. Some wastes can perfectly sensibly and safely be handled and disposed of locally in accordance with local judgements and decisions; and as you all well know this general approach - of delegating executive control, to the maximum extent possible, to local agencies (sometimes with the support of national guidelines or advice) - is fairly fundamental to our approach in this country.

35. Some pollution problems, however (of their nature - and for a variety of reasons), require the establishment of national policies, objectives or guidelines. And we also fully accept that some can justifiably and appropriately be considered on a Community wide basis. But it has been a consistent strand of British policy in relation to the Community's environment programme that the development of Community solutions should be in no sense an automatic process. Action at the Community level should be necessary and justified in each particular case which should then be looked at on its merits. At the first Council of Environment Ministers, in November 1974, the late Mr. Crosland put it that conditions in Member States are not geographically, environmentally or socially the same; and he underlined that there would always be situations and circumstances which were best handled at national or indeed local level, both in terms of what is done and of the techniques for doing it. He went on to say that it is neither sensible nor an efficient allocation of the Community's resources, to attempt to tackle at Community level, problems of this kind. If we were

to do so there was the danger that, by imposing uniform measures to deal with differing situations, we should produce the very kind of distortions that the Treaty is aimed at removing.

36. Now you may be saying "When is the man going to talk about air pollution and the United Kingdom's existing clean air legislation". I hope that you will forgive me that I have gone on at some length about Community policies, practices and procedures and the general UK attitude towards them. But the reason that I have done so is quite simple. It is that all these matters are just as relevant to air pollution control (and thus to our own UK attitudes, policies and legislation) as they are to other aspects of the "prevention of pollution and nuisances". What I have tried to do is to spell out the general background against which we are working, which we must keep in mind in considering possible effects on our own policies, practice and legislation.

37. Before, however, I do go on to discuss the details of the progress made to date within the Community on air pollution matters there is one further - peculiarly British - matter on which I should like to comment. I mean, of course, "best practicable means" (bpm). In his keynote address to the International Clean Air Conference in South Africa last year [5], Admiral Sharp, in referring to the quality objectives approach adopted by the Community said that many of this country, whilst still believing in bpm, were:-

> "coming to see that there are things to be said in favour of air quality criteria backed up by realistic emission standards which can themselves be based upon the best practicable means philosophy".

38. I myself believe that this remark was profoundly true. Plainly there are basic differences between the bpm approach and the quality objectives approach. But I do not believe that this means that they are - or need be - in any way incompatible. Certainly it does not seem that the Royal Commission on Environmental Pollution found them so. For - as I am sure you all well know - in its Fifth Report, on Air Pollution Control, [6] the Royal Commission, after a thorough re-examination of the whole bpm philosophy and approach, expressed itself in strong support of it. They said (paragraph 166):-

> "We have reached the firm conclusion that the bpm system should be continued. ...... The bpm system is consistent with the realities of pollution control. In principle it provides a flexible and sensitive means of achieving the balance of costs and benefits which should be the aim of control".

39. Indeed, not only did the Royal Commission confirm bpm, but they went on to propose that the concept should be expanded and given a new lease of life as a "best practicable environmental option" under which consideration would be given to the best way of disposing of unavoidable wastes, not only to air, but to all environmental media, so as to "minimise environmental damage overall" (paragraph 271). And in addition - and I emphasise

"in addition" - the Royal Commission also recommended that the time had come to give consideration to the establishment of "air quality guidelines", to provide, so-to-say, overall objectives and aims - a "framework for the rational consideration of air quality" (paragraph 169) - within which individual controls, whether by means of bpm of otherwise, would operate.

40. For my own part I see no fundamental conflict between bpm and the quality objectives approach. In the end it is the quality of the air we breathe and the water we drink that matters. But the maintenance and improvement of quality in environmental media can only be achieved through the imposition of controls on emissions. Harking back to what I said earlier about out attitude to uniform emission standards in an aquatic context, I am, of course, aware that there is an element of uniformity in the application of bpm to the control of industrial emissions to the atmosphere. National emission standards do exist which are uniform for particular industries. At the same time flexibility is left to vary the application to take account of special local circumstances. In sum we do have national emission standards; but they are applied flexibly. This is in no way inconsistent with opposition to rigid, international, uniform emission standards. And of course I do not need to stress to this audience that standards of emission are only a small part of "best practicable means"; nor that, as Frank Ireland reminded us in the third Sir Hugh Beaver Memorial Lecture,[7] bpm is a system which works and which "was endorsed by both Beaver and Flowers".

41. However, these - along with the other aspects of air pollution control discussed in the Royal Commission's Fifth Report - are all matters which are under consideration by Government, in the light both of the Royal Commission's recommendations and of the numerous comments that have been put to the Department in response to the consultation papers that we have circulated. And, for that reason, you will not expect me to say anything more about them today.

42. Let me now turn to the question of precisely where the Community's environment programme stands in regard to air pollution control. Progress to date has not in fact been very rapid since the Commission seem to have tended to give priority to water pollution control. However, as I have already mentioned, the programme itself does lay down a number of "pollutants for priority investigation"; in a first general category appear lead and lead compounds, organic halogen and organic phosphorus compounds and hydrocarbons with known or probable carcinogenic effects. In the specifically air category the further priority pollutants listed are sulphur compounds and suspended particles, nitrogen oxides, carbon monoxides, photochemical oxidants, asbestos and vanadium.

43. To date the Commission have worked - in the field of establishing scientific criteria - on lead, SO_2 (and suspended particulates), NO_x, asbestos, and vanadium. Reports on these substances exist in various stages of preparation, but so far the only ones to form the subject of proposals by the Commission to the Council for scientific criteria are lead, SO_2 and suspended particulates. These substances have also been the subject of proposals for quality standards submitted by the Commission. We

understand, too, that proposals have been formulated for both criteria and standards for NO_x and carbon monoxide, although they have not yet been submitted to the Council, some proposals on asbestos seem likely; but action on vanadium seems less probable - at any rate for the present.

44. So far as concerns the Commission proposals for SO_2 and suspended particulates, the criteria proposed - which was based on WHO work (very lergely derived from UK experience) - was put forward in the form of a resolution which seems broadly acceptable. Some of the proposed air quality standards are acceptable but others go beyond the scientific case which has been made for them. However, these are all matters which are currently under negotiation and, for that reason, I cannot go into details. And the same is true of a draft Directive on the Sulphur content of fuel oils which has been put forward and which we feel is not really very relevant to UK conditions.

45. As regards lead, the criteria put forward by the Commission were described as "quasi - quantitative relationship between dose and effect". The scientific basis for these criteria was not strong since they were merely derived from an arithmetical calculation relating intakes to blood levels and making the assumption (which seems to us a questionable one) that 25% of that intake comes from airborne sources. The directive for air quality standards for lead is still under discussion but the Council has agreed a four-year programme for the biological monitoring of blood lead levels; the results will in due course provide better data for future decisions.

46. In all the circumstances rapid progress in the Community on lead seems rather unlikely. For our part in the United Kingdom, we tend, in the present state of knowledge, to be opposed to a binding quality standard (and some other countries share our view on this) and would prefer to continue with our present direct action approach, which focusses on reducing the intake of lead by controlling and limiting the extent to which the metal is used in such products as paint, cooking vessels, petrol, etc., whilst at the same time exercising tight control over emissions from lead works.

47. So, in our judgement, a good deal more work looks like being necessary on the SO_2 and the lead proposals before agreement can be reached. Whilst these are still unresolved, it seems somewhat unlikely that early progress can be made on, for example, NO_x or carbon monoxide. Moreover, it is I think rapidly becoming apparent that the logical progression described in the Community's environment programme, from criteria to the definition of objectives and standards (which I have spelled out in some detail above) can well run into difficulties - fundamentally for the reason that the problems of establishing valid and scientifically based criteria are I think now acknowledged by all.

48. So that is where matters stand now. What of the future? Well clearly I cannot forecast in any sort of detail, because it is for the Commission to make proposals within the programme; and when it does so, this initiates a process of negotiation, the outcome of which is usually difficult to

foresee at the outset. However it does seem to me clear that action in relation to air pollution under the environmental programme is likely to continue to be fairly slow.

49. Quite apart from the difficulties which I have just mentioned, we know that the Commission has a number of priority areas for action which do not include air pollution. We understand that they would like to make fairly early progress on water pollution (especially in relation to blacklist substances); noise guidelines; "war on waste"; and one or two other matters. But it seems reasonable to assume that - whilst the Commission will no doubt seek to carry forward work on their SO_2 and lead proposals to the point of decision - other proposals in the air pollution field will be somewhat slow in coming forward.

50. No doubt the Commission will wish to give further thought to the situation created by the difficulty of establishing valid scientific criteria. Given this uncertainty and difficulty, the aim under the programme of establishing ambient air quality standards must seem a questionable one. The fundamental difficulty about taking such a step is of course that one may get the ambient standard wrong. If it is pitched too high, it can tend to be a licence to pollute - a problem which I believe the first Chief Alkali Inspector, Angus Smith, rapidly encountered over muriatic acid works - it annoyed him that although they could achieve much better than 95% removal, they were, in effect, licensed by law to emit 5%; he soon had that situation changed! The alternative - if standards are fixed too low - is equally troublesome. In such circumstances difficulties of implementation will be encountered; there will be a waste of resources; and a misleading impression of the degree of risk arising may well be given.

51. In such circumstances I do think that there is a strong case for pressing forward the quality objectives approach to the extent that current knowledge permits. Plainly - if we are talking about a matter of Community-wide concern, some action - some yardstick by which to judge pollution levels - may well be desirable. In such circumstances - acting in the light of criteria if possible but, if not, then of whatever scientific evidence is available - surely one way to make progress might be for proposals to go to the Council in a non-binding form, e.g. as a proposed Recommendation setting out "guide limits" as an indication of desirable levels to be achieved.

52. In saying this I should perhaps stress that I am not thereby suggesting that the United Kingdom should attempt to make the Community's environment programme woolly and non-effective; quite the reverse - I am looking for practical ways of making real progress. Apparent precision where there is none (and where the scientific basis for action is entirely uncertain) is simply "phoney" and can only bring the whole scientific and negotiating processes into disrepute.

53. Let us by all means act, when we must, at Community level. But in doing so, let us not fool ourselves. If clear criteria, objectives and standards can be established and negotiated between Governments to their general satisfaction, so be it. But if firm and binding conclusions are

either not necessary or cannot be reached in this way, let us not spurn lesser instruments which might provide valuable guidelines to member states in their attempts to improve environmental quality throughout Europe.

54. Let me now endeavour to sum up. In doing so I come back to the theme of my address - the possible effects of the Community's environmental programme on existing clean air legislation in this country. I have tried to indicate in the latter part of my talk that, in terms of immediate detailed impacts on our policies, practices, and legislation, it does not look as if the Community's environment programme will move very far or very fast. This is true for two basic reasons - first that the proposals that have already been put forward in the air pollution field have run into difficulties over establishing soundly-based scientific criteria which are likely to take time to resolve; second that, as I have indicated, the Commission's priorities for action in the present phase of work lie in other areas of the programme.

55. But I do not think for a moment that this means that we can simply conclude that the environment programme has no effect on air pollution control in this country. As a member state of the Community, negotiating all the time in Brussels on a vast variety of subjects in the environmental and related fields, we cannot fail to be influenced to some extent by the thinking we encounter. And we devoutly hope that we shall, for our part, be able to influence thinking both in the Commission and in other Member States.

56. We shall continue to urge the importance of the fundamental points we have made all along:-

i. the importance of adequate scientific preparation of proposals;

ii. the importance of restricting proposals for Community-wide action to those occasions when there really is objective justification for action at this level, rather than at the national or local levels;

iii. our conviction that environmental protection and improvement is best served by an approach based on the achievement of quality objectives;

iv. that, conversely, we do not see uniform and rigid emission standards as a suitable instrument, particularly where they would lead to pointless expenditure without environmental benefit.

And we hope to win an increasing measure of acceptance of - and even support for - the soundness of our approach.

57. If we can achieve this, then I think that we shall in a few years time be able to say, not that the Community's environment programme has no effect on our domestic policies, procedures and legislation, but that as a result of the stimulus provided by the exchange of ideas during the negotiation process in Brussels, there has been a convergence of approach rooted

in the very substantial area of agreement which already exists.

58. If so then, without in any way minimising what we may have to learn from our Community partners, I hope that we shall reach a situation in which legislation emerging from the Council in Brussels will reflect conclusions not very different from those that we might ourselves have reached, based on our long experience of air pollution control; and on the continuous new stimuli provided by such initiatives as the Fifth Report of the Royal Commission on Environmental Pollution and by such bodies as the National Society for Clean Air.

The views expressed in this paper are those of the author and not necessarily those of the Department of the Environment.

REFERENCES

1. Official Journal (OJ of the European Communities, No C112, 20 December 1973.

2. OJ, No C139, 13 June 1977.

3. Department of the Environment, Pollution Paper No 11, Environmental Standards: A description of United Kingdom practice, HMSO, 1977.

4. Council Directive (76/464/EEC), 4 May 1976; OJ, No L129/23, 18 May 1976.

5. P.G. SHARP - National and International Factors influencing changes in policy of Air Pollution Control, Keynote Address at International Clean Air Conference - Clean Air, Summer 1976, pp 6-10.

6. Royal Commission on Environmental Pollution, Fifth Report, Air Pollution Control: An Integrated Approach. Cmnd 6371, HMSO, January 1976.

7. F.E. IRELAND - Reflections of an Alkali Inspector, Third Sir Hugh Beaver Memorial Lecture - Clean Air, Summer 1977, pp 4-9.

NATIONAL SOCIETY FOR CLEAN AIR

44th CLEAN AIR CONFERENCE

SEPTEMBER 19 - 22, 1977

HARROGATE

AIR POLLUTION AND PLANTS

P.J.W. Saunders
Natural Environmental Research Council, London

136 North Street
Brighton BN1 1RG
England

1. INTRODUCTION

1.1 Air pollution is recognised as a hazard to man. It also has many other environmental consequences including adverse effects on plants and soils. Indeed plants are amongst the organisms most sensitive to air pollution. Experiments have demonstrated effects on plants which are of potentially great significance in agriculture, forestry and the natural environment. Confirmation of such effects in the field, however, is difficult to obtain. This is because the response of a plant is the product of complex interactions between plant, pollutant and environment.

2. ATMOSPHERIC POLLUTANTS

2.1 There is naturally a continuous exchange of elements, in elemental or compound form, between the atmosphere, plants and the soil. Additional quantities of such materials are released to the atmosphere as a result of man's activities. These additions are regarded as pollutants if they perturb environmental processes including those involved in plant growth and development.

2.2 The many pathways travelled by air pollutants which come into contact with plants are basically of two main kinds:

i those involving direct deposition upon the aerial parts of plants causing direct injury to foliage, etc.

ii those involving entry of pollutants into the soil where they disturb the chemical and microbiological processes involved in plant nutrition. Certain pollutants (e.g. metals) may also pass unchanged to the soil around the roots and then be taken up by the plant.

Generally, direct injury to foliage, etc. is associated with dry deposition of particulates and especially gases. Soil contamination tends to be associated more with wet deposition (e.g. acid rain) although dry deposition of gases can also be an important pathway.

2.3 The ultimate effects of pollution upon plants depend very much on the physical and chemical form of the pollutants involved, and their distribution in time and space. Those of practical interest in the U.K. are listed in Table 1. They fall into two broad, but not exclusive categories:

i those emitted from many sources and having a widespread distribution (e.g. smoke, ozone (O_3), sulphur dioxide (SO_2), sulphate (SO_4).

ii those emitted primarily by certain industrial and other activities and having relatively localised distribution (e.g. most metals, fluorides, ethylene).

The relative importance of a pollutant is not, however, governed simply by the coincidence of its distribution in time and space with the distribution of plant life. There are a number of important variables associated with both pollutants and plants, and their interactions with the environment.

2.4 During this Conference, other speakers will discuss the monitoring, measurement and behaviour of pollutants. It is sufficient to note here that most monitoring is conducted in urban and industrial areas, and most measurements are of average concentrations over periods of 24 hours (smoke, SO_2) or longer (e.g. SO_4 ions in rain). Unfortunately, the rural and semi-urban areas which are important to agriculture, forestry and the natural environment receive little attention. Such areas are usually exposed to relatively low average concentrations of pollutants (e.g. 25-50ug SO_2/m^3air/24hr) although for short periods (e.g. 5 min to 2 hrs), values of 2 to 10 times greater may occur. It is these high peak values that are associated with incidents of foliar injury to sensitive plants.

2.5 It is rare for one pollutant to occur in isolation. The atmosphere usually contains a mixture of pollutants in which one may be dominant. Certainly each pollutant is distributed uniquely in time and space. Most exhibit individual patterns of seasonal behaviour. Many also exhibit daily patterns in concentrations; this applies especially to those associated with photochemical processes which operates only during day-light hours.

2.6 A wide range of environmental parameters (e.g. sunlight, temperature, humidity, rain fall, wind speed, wind direction and topography) determine the distribution of pollutants. The distribution of plants, and their growth and development processes, are also strongly influenced by the same environmental factors and others such as soil type, water availab-ility and disease. Furthermore, these factors can directly affect the response of a plant to a pollutant. Plants thus live in a dynamic environment in which air pollution is only one of many constantly changing variables.

3. PLANTS AND POLLUTANTS

3.1 There is a large body of information on the effects of air pollutants upon plant life. Most of it refers to the effects of high concentrations of single, gaseous pollutants upon a few young plants of one species or cultivar. These results have been obtained by experimental exposures of plants to constant concentrations of a pollutant under controlled condit-ions. Thus, they are not strictly comparable with conditions in the real environment. Nevertheless, they do demonstrate certain characteristics of plant response.

3.2 There are marked differences in the sensitivity between individual species and cultivars to each pollutant. Such differences may also occur between individual plants of a given population. The order of sensitiv-ity changes, however, with concentration and duration of exposure, age of

plant and with the pollutant. No hard and fast rules apply but generally young plants or plant tissues are more sensitive than older ones. Also sensitivity to SO_2 pollution tends to be the reciprocal of sensitivity to fluorine pollution (F, HF).

3.3 A plant reacts initially to a pollutant by undergoing physiological and biochemical changes to adapt itself to its changed environment. Respiration and photosynthesis are usually affected, and residues of pollutants (e.g. SO_4 =, fluorine, metals) may be accumulated in the tissues of the plant. Such responses may be detected at concentrations of pollution lower than those normally associated with inhibition of growth or foliar injury. Any exposure which exceeds the capability of the plant to adapt to its environment, however, results in more extreme biochemical and physiological changes with permanent effects upon the plant. Reduced growth, early senescence, reduced seed production and, in extreme cases, foliar injury may occur.

3.4 It is important to note that there is a threshold combination (limit) of concentration and duration of exposure to most pollutants for each response. The combination of concentration and of duration of exposure constitutes the pollutant dose received by the plant. Basically, concentration and duration are reciprocal factors. Thus a reduced concentration can be balanced by increased duration of exposure, although concentration is the more dominant component of dose. Below the threshold limit, no response occurs. Above the threshold limit, the magnitude of the response is related to the dose (dose/response function).

3.5 Threshold limits and dose/response functions can be established by careful experimentation for various responses of individual plants exposed to relatively high doses of individual pollutants. The relations between each type of response, however, are complex and differ between pollutants. Both relationships change dramatically with the introduction of other variables such as fluctuating concentrations of a pollutant, mixtures of pollutants and changes in environmental factors such as wind speed and water availability. For instance, the threshold limit for SO_2 injury to the foliage of lucerne can be raised by a factor of two merely by reducing the availability of water to the plant and inducing wilt conditions.

3.6 Mixtures of pollutants introduce a number of possible interactions, the effects of which may be greater than the sum of the effects of the individual pollutants involved. Such effects have been observed in peas and beans exposed to mixtures of SO_2 and nitrogen dioxide (NO_2) and in trees exposed to mixtures of SO_2 and particulates (e.g. smoke). Still more complex responses are involved where air pollutants affect plants directly (e.g. SO_2 injury to foliage) and indirectly (e.g. acid rain effects in soils resulting in changes in plant nutrition).

3.7 These problems affect our ability to determine precisely the impact of air pollution in the UK upon plant life. These difficulties are multiplied by the ease with which the symptoms of injury to plants are confused with those of disease, nutrient deficiency and 'physical' damage.

However, two broad types of symptoms can be identified.

i Severe or acute injury resulting from exposure to high concentrations of a pollutant over short periods of time (e.g. 800 $\pm$ 200 µg SO_2/M^3 air/1 to 24 hr periods). Symptoms include marginal and top necrosis of leaves, die-back of shoots, etc. Necrotic areas are often bleached white although they may become brown and watersoaked (SO_2) or bordered with a line of red cells (HF). Other symptoms include black stipples (ozone), bronzing (PAN) and distortion of leaves (ethylene). Early leaf and flower drop is common.

These are extreme responses observed only in badly polluted urban and industrial areas, except for certain very sensitive plants (e.g. tobacco cultivars sensitive to c. 10 pphm ozone).

ii chronic injury resulting from exposure to lower concentrations of a pollutant over prolonged periods of time. Visible symptoms are usually limited to a vague marginal and interveinal yellowing (chlorosis) of leaves which may be associated with advanced senescence. Such symptoms have been observed in plants exposed to 450 $\pm$ 200 µg SO_2/M^3 air over several days. At still lower concentrations over longer periods of time (e.g. 150 $\pm$ 100 ug SO_2/M^3 air/weeks or months) there are few overt symptoms other than advanced senescence ('cryptic' or 'invisible' injury).

3.8 The above example are for a higher plant which is sensitive to SO_2 pollution. A few plants and many micro-organisms (e.g. lichens and fungi) are much more sensitive and will not be found in areas where SO_2 concentrations exceed 50-100 µg SO_2/M^3 air/24 hr. Similar examples may be quoted for other pollutants.

3.9 Generally, loss of yield is related inversely to the area of foliage suffering from acute injury. However, most interest in the UK is focussed on the rural and semi-urban environment where one would anticipate chronic and especially 'cryptic' injury to occur. There has been a great expansion of research in this area in recent years. Later speakers will discuss the results of such work. It is sufficient to note here that potentially severe effects upon the growth and development of plants may arise as a result of exposure to very low concentrations of pollutants, notably SO_2, O_3, NO_2, fluorides and acid rain. The nature of these effects, however, is dependent upon the life cycle and communal existence of the plants involved.

4. PLANT POPULATIONS, COMMUNITIES AND SYSTEMS

AGRICULTURE

4.1 Most plant cultivars in agriculture and horticulture are grown as monocrop populations. The monocrop is a simple community composed of a uniform population of one cultivar. This is exposed to pollution throughout its growth cycle (April to September for most annual crops although

some, e.g. winter barley, are exposed from about October to July). A few crops may have longer cycles. The identification of plant responses to air pollution would thus seem to be simple. However, the soil is cultivated to achieve maximum yields. A 'lavish' supply of nutrients may therefore obscure the effects of a pollutant and prevent gradual deterioration of the soil. Some disease organisms are also very sensitive to pollution thereby altering the pattern and yield losses associated with certain diseases.

4.2 The most serious problem to resolve, however, is the discrimination of the effects of a pollutant from those of other environmental stresses. In the UK most crops are exposed to levels of pollution which have effects on yield, etc. well within the limits of those associated with such stresses. Consequently, the use of fumigation chambers for experimental investigations can itself alter the environment (e.g. by reducing light, by raising ambient temperatures) sufficiently to cause effects on growth of equal or greater magnitude than those caused by pollution.

FORESTRY

4.3 The same problems apply to commercial forestry plantations. However, forests are grown generally on marginal soils without the benefit of repeated applications of fertilisers. They are exposed to pollution for periods of 10-30 years, although on average the levels of pollution are less than those experienced by many agricultural crops. Forests therefore face the prospect of slow degradation by both direct and indirect (soil mediated) exposure to pollutants. This is basically the question raised by the long range transport of sulphur compounds from the UK and other countries, and their deposition as acid rain in Southern Scandinavia. Most scientists believe, in fact, that the long term effects of acid rain upon trees and tree growth in Scandinavia are not proven. The leaching of nutrients from soils may well, however, contribute to the acidification of lakes and streams in certain areas.

SEMI-NATURAL AND NATURAL COMMUNITIES

4.4 Permanent, upland pastures and many woodlands are much more complex communities composed of many plant species. This applies to certain lowland systems including fenlands, meadows and many parks. In these cases, the component species may exhibit very different sensitivites to particular pollutants. Obviously those most sensitive species are inhibited from further development and may even be eliminated from the community. A structural change thus occurs in which existing or invading species of lesser sensitivity occupy the vacant ecological niches. Long term changes associated with gradual degradation (e.g. soil acidiciation) also may occur.

4.5 To a certain extent these effects of pollution can be modified by structural factors. In forests and woodlands, for example, the taller trees provide a canopy which effectively screens out much of the pollution.

Concentrations of individual pollutants within the canopy are thus considerably reduced and more sensitive herbs and shrubs can survive. (This principle is utilised by landscape architects around certain industrial developments to reduce their impact upon residential and agricultural areas). Damage to the crown of a tree reduces the cover provided by the canopy and may also induce the tree to produce shrub-like adventitious shoots at the base of its trunk. The structure and the composition of the community are usually degraded where such relatively severe effects on trees occur.

4.6 There is also evidence of selection of less sensitive individuals amongst populations of sensitive species. This allows the development of a replacement population able to survive exposure to pollution. The extent to which such selection occurs in nature is uncertain but examples of SO_2 resistant grasses, docks and tree species are known. These have been put to practical use in the reclamation and revegetation of derelict land and waste heaps in industrial areas. Some success has also been achieved by plant breeders in selecting and reproducing strains of cultivars (e.g. of tobacco, citrus, gladioli, some conifers) which are resistant to individual pollutants, for use by the agricultural and forestry industries.

5. ECONOMIC CONSEQUENCES

5.1 Various attempts have been made to assess the economic implications of air pollution damage to plants. Most of these estimates are based on experiments with grasses, cereals (e.g. barley), cash crops (e.g. tobacco, lettuce, spinach) and certain conifers. The most recent estimates of damage to UK agriculture suggest losses of between £110m - 200m $\pm$ £150m at current prices. Recent research suggests, however, that these losses may be greater than supposed. Any estimate of national loss of plant production must be speculative at this stage. However, I would hazard a guess at 15% $\pm$ 10% of total production, costing between £350m and £450m/yr. The majority of this economic damage is borne by agriculture and forestry but some allowance must be made for those losses incurred by home gardeners and by those concerned with amenity plantings (e.g. local authorities, industry, nurserymen). It excludes, of course, any social penalties associated with damage to the natural environment and to conservation interests.

6. SOME REFERENCES

1. Department of the Environment (1976) Effects of airborne sulphur compounds on forests and freshwaters Pollution Paper No. 7 HMSO, London.

2. Inter-Research Council Committee on Pollution Research (1975) Some gaseous pollutants in the environment Rept. of a Seminar. NERC, London (out of print).

3. Mansfield, T.A. ed (1976) Air pollution and plants Cambridge University Press.

4. Mudd, J.B. & Kozlowski, T.T. eds (1976) Responses of plants to air pollution. Academic Press, London.

5. Saunders, P.J.W. (1976) Estimation of pollution damage Manchester University Press.

6. Svenson, B.H. & Sonderlund, R. eds (1976) Nitrogen, Phosphorus and Sulphur - global cycles. SCOPE Report (7). Ecol Bull (22), Swedish Natural Sci. Res. Council, Orsumdsbro.

TABLE 1 PRINCIPLE ATMOSPHERIC POLLUTANTS AFFECTING PLANT LIFE

	Principal effect
1. Gases	
Carbon dioxide (CO_2)	Indirect - climate change
Sulphur dioxide (SO_2)	Direct - phytotoxic
Oxides of nitrogen (NOx)	(Direct - phototoxic (Indirect - climate change
Hydrogen fluoride (HF)	Direct - phytotoxic (see also 'fluorides' below)
Ozone (O_3)	Direct - phytotoxic
Peroxyacyl nitrates (e.g. peroxyacetyl nitrate - PAN)	Direct - phytotoxic
Ethylene (C_2H_4)	Direct - phytotoxic
Aldehydes	Direct - phytotoxic
2. Particulates	
Smoke and soot (C)	Direct - physiological change
Dust and Grit	
Silica	Direct - physiological change
Limestone	Indirect - soil modification
Metals (e.g. lead, cadmium, iron)	Indirect - soil contamination; may lead to phytotoxicity *via* roots. Also may be hazardous to animals eating contaminated foliage.
Fluorides	(Direct - phytotoxic (Indirect - soil contamination - but little uptake *via* roots. Also hazardous to animals eating contaminated foliage.
Precipitation (rainfall)	
Acid rain (H^+ ions)	Indirect - soil modification and acidification of surface waters
Metals (e.g. Mn^{++} ions)	Indirect - soil contamination (see above)
Salts (e.g. $SO_4^=$, NO_3^- ions)	Indirect - soil modification (may supply essential growth elements)

Notes: (i) These pollutants are not listed in any particular order of importance in relation to their effects on man, plant life, etc.

(ii) The list is not entirely comprehensive (e.g. hydrogen sulphide - H_2S - is phytotoxic but is not regarded as a common pollutant).

(iii) Only limited account is taken of interactions between pollutants and of 'secondary' effects (e.g. SO_2 can contribute to the acification of soil).

NATIONAL SOCIETY FOR CLEAN AIR

44th CLEAN AIR CONFERENCE

SEPTEMBER 19 - 22, 1977

HARROGATE

THE INFLUENCE OF AERIAL POLLUTION ON AGRICULTURAL CROPS

Professor C.P. Whittingham
Rothamsted Experimental Station

136 North Street
Brighton BN1 1RG
England

Pollution sources which have effects upon agriculture can be classified in at least six groups:

1. Mining and smelting industries.
2. Emissions from other industrial works.
3. The effect of rainfall whose composition has been modified by 1 & 2.
4. The influence of motor exhaust fumes.
5. The disposal of sewage sludge and slurries and composted refuse.
6. The use and distribution of fertilisers and pesticides.

From such sources non-naturally occuring elements may be introduced into the ecosystem. But also many chemical elements naturally present in the environment, which in trace quantities are essential for plant and animal nutrition, can in larger quantities, or when in serious imbalance, cause crop loss or failure. The end result may be either a reduced yield or even plant and animal death; also the quality of food used both for human and animal consumption may be depreciated. To evaluate the effect of additional sources it is necessary to establish the base level of several naturally occurring elements prior to the industrial development, to characterize the course of each added element, to understand the method by which it is dispersed through the ecosystem and to quantify the biological effects which it can cause.

Clearly to consider these propositions in the general sense of all pollutants which influence agriculture and also to consider how far agriculture itself may produce pollutants which influence ecosystems would be beyond the scope of the present short presentation. Therefore, this discussion will be confined to the effect of certain pollutants which are dispersed through the air which are suspected of having possibly a widespread influence on agricultural production in a considerable part of the acreage of the U.K..

From an economic point of view it is less important to evaluate effects of high levels of pollutants which are probably confined to very limited acreages immediately adjacent to an emission source. If significant effects are established as resulting from a long term exposure to a relatively low level of pollutant, these can be much more important because of the large acreage involved. Furthermore, such effects need not necessarily be associated with any visual symptoms and may therefore pass unnoticed. Public attention is immediate if near to an industrial operation there is tree and plant death resulting in a devastated area. But this should not obscure the need to consider whether there are any effects resulting in significant economic loss which are not accompanied by any obvious visual changes in the ecosystem.

The main types of aerial pollutants which influence plant growth can be divided into four groups:

(i) Those arising from the burning of fossil fuels including sulphur dioxide and smoke;

(ii) Specific emissions from certain industrial processes such as fluorides, ammonia or chlorine;

(iii) Those arising from motor vehicle exhausts including hydrocarbons,

nitrogen oxides and ethylene;

(iv) The secondary pollutants which form as a result of photochemical action between certain organic chemicals and oxidants such as ozone and nitric oxides.

The main effect of these pollutants at relatively high concentrations is fairly readily distinguished.

Sulphur oxides commonly emitted during the smelting of ores and the combustion of coal and petroleum fuels produce significant effects on both animals and plants. In plants there is first a "water-soaked" appearance of the tissue followed by an irreversible killing of leaf tissue and the production of characteristics marginal and inter-veinal yellow to light-brown to white necrotic areas. At lower concentrations the leaves may accumulate an abnormally high amount of sulphate but continue to appear normal although possibly showing some degree of chlorosis.

Fluorides are emitted from industries in which ceramic clay products and glass are manufactured and from the aluminium, chemical and phosphate fertilizer industries. Fluoride may be emitted either as gaseous hydrogen fluoride or as particulate calcium fluoride. After entering the plant fluorides are translocated to the margins and tips of leaves where they accumulate. Symptoms begin as a scattered chlorotic fleck on the tips and margins of middle-aged leaves and flecking progressively becoming more intense and extending downwards along the margins. Eventually this leads to tip and marginal chlorosis. Very high levels of fluoride can accumulate within local regions of the plant. The leaf tissues collapse and livestock eating the tissue show fluorosis; a disease first noted in Iceland nearly 1000 years ago after volcanic eruptions.

Nitrogen oxides are produced by the combustion of organic matter and are introduced into the atmosphere from engine exhausts and furnace emissions. They result in reduced plant growth.

Ethylene arises from the combustion of natural gas, the burning of gasoline and certain chemical processes. Unlike the other pollutants, ethylene interferes with the normal growth and development processes of the plant. According to the conditions it can result in growth retardation, abnormal growth of shoots and leaves, leaf and flower drop and irregular flower development.

Ozone is present by natural origin and is produced photochemically by reactions in the atmosphere between nitrogen oxides and organic compounds, mainly from car exhausts. Acute symptoms include tissue collapse, bleaching and necrosis. At lower concentrations leaves may develop discrete spots on the upper surface on which a reddish-brown pigment is deposited. Measurements in the U.K. near Ascot in 1975 and 1976 showed levels of ozone of the same order as those reported to cause plant damage in the U.S.A..

Peroxyacetyl nitrate (PAN) is a photochemical reaction product of nitrogen oxides and hydrocarbons largely arising from vehicle exhausts. The

response is often the development of silver or bronze patterns on the lower leaf surface followed by necrosis and chlorosis of the upper surface. The significance of PAN in the U.K. is still not known.

Different crop plants show considerable variation in their susceptibility to pollutants. Species sensitive to sulphur dioxide include barley, oats and wheat in that order, whereas maize is relatively resistant and sugar beet intermediate. In the case of ozone, oats and potatoes are relatively sensitive, maize and wheat less so, and beet most resistant. Amongst horticultural crops tomatoes are sensitive, onions are less so and carrots the least sensitive. Maize is particularly sensitive to fluoride with barley,oats and wheat progressively less so. With respect to PAN,sensitive species include oats and beans with wheat intermediate and maize the most resistant. For oxides of nitrogen, barley is most sensitive with maize and wheat intermediate together with potato. It should be appreciated that these are broad generalisations and in fact there is a considerable degree of variation in the resistance of different cultivars of a crop plant. Perhaps the best known example of this is the marked difference in sensitivity of different varieties of tobacco to ozone shown in the U.S.A.. In this country we are beginning to find at Rothamsted marked differences in sensitivity between barley varieties. In general spring barleys are less sensitive than winter barley to fluoride. Bean varieties show a sixfold variation in sensitivity to PAN. It must be appreciated that relatively few experiments have been conducted on a wide range of cultivars of any one species grown under identical and controlled experimental conditions. According to the light intensity and humidity in which the plants are grown and the water supply the response of the plant will be variable. Furthermore, the age of the plant at the time of exposure is a critical consideration. Many of the conclusions concerning sensitivity quoted above have been obtained from studies where plants have been exposed in fumigation chambers to a constant dosage of one chosen pollutant. However, in natural conditions the plants are exposed to rapid changes in concentration and these are often related to changes in environmental conditions; furthermore, there is often more than one pollutant present. There is considerable doubt as to whether information, obtained from fumigation chambers in which plants are exposed to 24 hours of each day to a constant level of a single pollutant, are particularly relevant to considerations of field-grown crops. Furthermore, experiments in fumigation chambers sometimes use concentrations of pollutant which are so high that they occur naturally only over relatively restricted acreages.

Considerable evidence suggests that plants grown in low fertility areas differ in their sensitivity to certain aerial pollutants. Thus it has been shown in the U.S.A. that application of autumn fertilizer to trees of white pine (*Pinus strobus*) reduced damage due to ozone. On the other hand, tomato plants given optimal levels of nitrogen, calcium and phosphate were more sensitive to damage from fluoride. There is no simple generalisation that can be justified.

Much of the discussion concerning the economic loss to agriculture resulting from aerial pollution has been based on studies in experimental fumigation chambers. This is because of the experimental difficulty in

duplicating the field situation in terms of the ever-changing environmental conditions and pattern of pollution exposure. It becomes necessary to ask whether we cannot conduct our experiments in the field itself. In practice this proves a formidable task but I believe that we have to use experimental procedures in the field to identify certain crucial aspects of the problem of pollutant-crop interaction. Information obtained from such experiments can then be compared with that from field surveys. Unfortunately, at the present time, we are far from being able to estimate the agricultural effects of aerial pollutants with any degree of precision. However, at Rothamsted, we have begun to attempt to evaluate the loss which may arise from the effect of aerial pollution on one particular cereal crop, barley.

Our investigations were conducted in the vicinity of Bedfordshire's four major brickworks which are situated on the valley that runs south south-west from Bedford to Woburn, an agricultural area.

The clay used to manufacture the bricks is high in organic matter, approximately 5%. When the bricks are fired the organic matter burns to make the kilns virtually self-firing, a factor of considerable economic importance. It is the incomplete combustion of the organic material during the firing that gives rise to three major pollutants, sulphur dioxide, fluoride and mercaptans. The mercaptans give the fumes their characteristic odour but are not thought to be harmful to plants. Both sulphur and fluoride have been shown to be harmful to plants, the nature of damage being dependent on the concentration of the pollutant, the time of exposure and the environmental conditions during exposure. Stewartby brickworks is the largest of the works and has a capacity for producing two million bricks per day and emits up to 87 tons of sulphur dioxide and 0.8 tons of fluoride per day. Under adverse environmental conditions the pollutants may accumulate and sometimes specific episodes occur during which plants in the immediate vicinity of the works are visually damaged. Such episodes are rare and in the vicinity of the works the normal ambient levels of pollution are only slightly increased. The last incident when visual damage was recorded was in 1968 (Chamberlain, 1969).

An initial survey of the pollution in the area was made by analysing hawthorn leaves. Hawthorn was chosen because it occurred widely in the hedgerows of the area. Leaf samples were taken throughout the growing season at various distances from the brickworks. These were analysed for sulphur and fluoride, as percentage dry matter. Sulphur analysis was by x-ray fluorescence spectrometry (Brown and Kanaris-Sotiriou, 1969) and fluoride using a specific ion electrode (Baker, 1972). The fluoride content decreased approximately exponentially with distance from the works, whereas the sulphur content showed a more gradual decrease with distance. This difference in distribution is presumably related to the physical nature of the pollutants, since probably half the fluoride is emitted as gas and the remainder as a particulate deposition. Particles will tend to fall out over a shorter distance than gaseous material. A map of the area showing isopleths relating equal levels of fluoride in vegetation, clearly showed the effect of the prevailing south-westerly winds (Fig. 1). By contrast topographical features had little effect since the height of the

factory chimneys is equal to that of most hills in the neighbourhood. Circumstantial evidence that the sulphur and fluoride content of the vegetation are related to the activity of the brickworks emerged when data for 1973 were compared with those of 1972. Because of the economic recession certain of the works were closed in 1973 and there was a clear effect on the sulphur and fluoride content of leaves produced in the following season.

The primary objective of our investigation was to determine the possible effects of aerial pollutants on the growth and yield of cereals under natural conditions and in the absence of visual damage. We therefore sought to grow cereal crops in the field in the normal ambient atmosphere after it had been cleaned by filtration. Our first attempts were to grow spring barley, var. Julia, in plastic-covered, hooped channels of a type readily available commercially. Into these houses was blown either field air, or air filtered through a dust filter, or air filtered through active charcoal, calcium carbonate and a dust filter. Analysis of the air inside the chambers showed that the sulphur dioxide content was reduced to a very low level; when the ambient air contained between 75 and 100 $\mu g\ m^{-3}$ sulphur dioxide daily mean, the mean sulphur dioxide in the filtered chamber was 6 $\mu g\ m^{-3}$. The ambient fluoride level varied between 0.6 and 1.3 $\mu g\ m^{-3}$ but was reduced in the filtered house to a value less than 0.07 $\mu g\ m^{-3}$. These analyses were obtained by bubbling gas through suitable chemical absorbants following the procedures developed by the Warren Spring Laboratory (Bailey et al., 1970). Even in the plastic houses without chemical filtration the sulphur dioxide content was reduced due to absorption on the walls; the fluoride content was reduced by 30% in the unfiltered house, and by 64% in the house with a dust filter but without chemical filtration.

Plant harvests were taken throughout the growing season and the dry vegetation analysed for sulphur and fluoride content. Analyses were also made of the crop growing in the outside air in the same field. The sulphur content of the leaves was generally greater for plants from all three houses as compared with plants grown outside. At the beginning of August the values were:-

> 0.7, 0.9, 1.13 and 0.34% for the charcoal, dust-filtered, unfiltered houses and the outside plot respectively.

By contrast fluoride levels were:-

> 13, 15, 36 and 74 for plants from the charcoal, dust-filtered, unfiltered houses and outside plot respectively.

There was no sign of visible damage on any of the barley plants. During the season damage was seen on gladioli, which are very sensitive to fluoride (Thomas and Hendricks, 1956), growing in the open in the field and in the unfiltered chambers, but not in the filtered chambers. When the growth of the barley plants was examined the rate of increase in dry weight was significantly higher for plants grown in the chemically filtered chamber as compared with those in the unfiltered chamber. Addition of further amounts of sulphur dioxide to the atmosphere of the chamber

resulted in a further decrease in growth.

The analyses of plant material clearly indicated that the growing conditions within the chamber are quite different from those outside. For example, the sulphur content of the leaves from plants outside was half or less that of those from any of the chambers. Furthermore, the outside plot was approximately 20 days behind in development and harvest was correspondingly delayed. The temperature within the plastic hoops averaged 6 to 7°C above that in the field outside, the humidity was higher and the light intensity was 20% less. It is clearly difficult to separate any growth effects due to filtration of pollutants from changes which result from small but complex changes in the micro-environment. Our earlier experiments served to emphasize the difficulty of establishing clean air conditions in the field whilst maintaining all other environmental factors as far as possible unchanged.

In subsequent experiments we have modified the design of the plastic hooped chamber by decreasing its dimensions to 5 x 3 m and increasing flow rates to give two to three air changes per minute. The temperature difference has been reduced to less than 2°C between inside and outside. The sulphur content of plants grown in the modified chambers in the absence of filtration and plants grown outside were similar and higher than for plants grown in filtered chambers. Nevertheless there was a still greater increase in yield of dry matter for plants in the filtered chamber compared to outside plots than in the case of the earlier experiments. We have continued to use this modified hooped plastic chamber in our subsequent experiments.

We have also developed an alternative type of chamber with an open top; this has been based on the studies at the Boyce-Thompson Institute in New York where such chambers have been used for fumigation studies (Mandl et al., 1973). The chambers are composed of cylinders of rigid Novolux PVC sheeting 3 m high and 3 m in diameter. Air is blown into the chambers through polythene lay-flat tubing that is placed around the base of the inside of the chamber, and the air passes out of holes between 20 cm and 30 cm from the ground level. The flow rate is such that there are between three and four air changes per minute. With this system we are aware that the flow rate is inadequate to prevent downward movement of ambient air into the chamber. The rate of movement of the air upwards from the fan system is of the order of 15 cm sec^{-1}, whereas on a day with a force three wind (horizontal speed 400 cm sec^{-1}) vertical eddies of 40 cm sec^{-1} might be expected. However, the concentration of pollution in the ambient atmosphere is closely correlated with wind speed, since on windy days pollutants are more widely dispersed. On still days when the level of pollutants is higher the filtration system is more effective. In practice we have shown that the level of sulphur dioxide in the filtered, open-top chamber is reduced on average by 50%. When the ambient concentration is high outside the chamber the concentration within the chamber is also relatively high; on still days it was generally reduced below 25 µg m^{-3} and the highest concentration ever measured in a filtered open-top chamber was 90 µg m^{-3}. Measurements show that within the open-top chamber the temperature never exceeds that outside by more than 2°C; there is a

downward temperature gradient within the chamber of up to 0.7°C m^{-1}. The relative humidity is approximately the same within and without the chamber and the light intensity is reduced within the chamber by approximately 10%. Rainfall will not be as high within the open-top chamber as outside. Consequently measurements were made throughout the growing season of the soil moisture content using a neutron probe, and water was added to the soil at 14 day intervals as necessary to keep the soil moisture level approximately equal inside the chamber and outside. We have experimented with attaching collars of different designs around the top of the chambers in an attempt to improve the efficiency of the filtration.

In 1976 spring barley, var. Abacus, was grown at Woburn in outside plots and within four open-top and two closed hooped chambers of the type already discussed. Two of the open and one of the closed chambers were supplied with clean air, the remainder with field air. Throughout the growing season the average concentration was 61 μg m^{-3} (0.02 p.p.m.) sulphur dioxide and 0.8 μg m^{-3} fluoride. The growth rate of the plants in the filtered chambers of either type exceeded that in the unfiltered chambers and in the outside plots. This difference in growth resulted in considerably higher grain yields in the filtered chambers, the mean for the filtered chambers being almost double the mean value for the chambers without filters and 60% greater than for the outside plots. When differences in chamber design were taken into account the closed filtered chambers produced the highest ear weight, whereas the closed chamber without filtration gave the same weight as for plants grown outside except that they matured earlier in the season. The open filtered chamber gave a significantly increased ear weight compared with plants outside but the open chamber without filtration gave a significantly poorer yield than the outside plots (Fig.2). Sulphur content of the leaves was greatest in outside plots, somewhat reduced in closed chambers without filtration and significantly reduced in open chambers both without and with filtration (Fig. 3). The fluoride content of leaves was equal and at the highest value for plants in the outside plots and for those grown in the open chambers without filtration. They were significantly lower in the open chambers with filtration but were least in plants grown in the closed hooped chambers (Fig.4). This confirms our opinion that the closed chambers are most effective in eliminating pollutants but that the filtration in the open chambers did remove a considerable portion of fluoride. It is clearly difficult to relate the sulphur analyses of plant material to the efficiency of filtration since sulphur is relatively mobile in the plant and can be taken up both through the roots and from the leaves.

Other workers have reported a reduction in yield in perennial ryegrass (Lolium perenne L.) due to exposure to sulphur dioxide in the absence of visible damage. Bleasdale (1973) demonstrated yield loss in the polluted air of Manchester when sulphur dioxide was thought to be the injurious agent. Subsequently Bell and Clough (1973) found a reduction in yield of 50% when plants were continuously exposed to air containing 191 ug m^{-3} sulphur dioxide. Effects on stomata of relatively low concentrations of sulphur dioxide were observed in maize and broad bean (Biscoe, et al., 1973 and Wellburn, et al., 1972). Holmes et al., (1915) and Cowling and Lockyer

(1976) have found a beneficial effect of atmospheric sulphur dioxide on growth of ryegrass and barley; they have emphasized the relationship between sulphur supplied from the soil and from the atmosphere.

Our investigations have illustrated the large number of environmental factors which influence cereal growth and yield and the difficulty of removing one of these (aerial pollutants) without altering others. However, we believe that by the use of two contrasting types of chamber which modify the environment within the chambers in different ways, it is possible to draw conclusions about the effect of pollutants. We believe it is significant that in both types of chamber the inclusion of filtration results in an increase in yield even although in the absence of filters one chamber results in a slight increase in yield and the other in a significant decrease. Since the chambers differ in the efficiency with which they filter different pollutants, we hope by detailed studies to be able to separate the effects of individual components in the polluted atmosphere. Our present data are not sufficient to enable us to make such deductions at this stage.

We accept that the results we have presented related to a limited number of growing seasons and in the last two seasons when our chambers have performed most effectively the climate has been unusual. We shall continue to make observations in subsequent seasons to confirm our present findings. We also intend to extend our investigations to different varieties of barley and other cereals because our parallel studies in the laboratory have indicated a wide range of sensitivities amongst cultivars of barley commonly grown in the United Kingdom. We think it is important to make observations of other crops grown in field conditions and we would hope to extend our studies to other crops, e.g. grass, covering a large acreage nationally. Our present conclusion must be that there is a strong indication that pollutants at levels which have been regarded in the past as acceptable may be resulting in significant yield losses in British Agriculture.

REFERENCES

Bailey, D.L.R., Killick, C.M. and Trott, P.E. (1970) Standard method for sampling airborne fluorine compounds. Warren Spring Laboratory Method LR129(AP).

Baker, R.L. (1972) Determination of fluoride in vegetation using the specific ion electrode. Anal.Chem., 44, 1326.

Bell, J.N. and Clough, W.S. (1973) Depression of yield in ryegrass exposed to sulphur dioxide. Nature, Lond., 241, 47.

Biscoe, P.V., Unsworth, M.H. and Pinckney, H.R. (1973) The effects of low concentrations of sulphur dioxide on stomatal behaviour in *Vicia faba*. New Phytol. 72, 1299.

Bleasdale, J.K.A. (1973) Effects of coal-smoke pollution gases on the growth of ryegrass (*Lolium perenne* L.). Environ. Pollut., 5, 273.

Brown, G. and Kanaris-Sotiriou, R. (1969) The determination of sulphur in soils by X-ray fluorescence analysis. Analyst, 94, 782.

Chamberlain, A.C. (1969) Fluorine from brickworks in Bedfordshire. Personal communication (A.E.R.E. Harwell).

Cowling, D.W. and Lockyer, D.R. (1976) Growth of perennial ryegrass (*Lolium perenne* L.) exposed to a low concentration of sulphur dioxide. J. exp. Bot., 98, 411

Holmes, J.H., Franklin, E.C. and Gould, R.A. (1915) Report of Selby Smelter Commission, U.S. Bur. Mines Bull. 98.

Mandl, R.H., Weinstein, L.H., McCune, D.C. and Keveny, Monica (1973) A cylindrical, open-top chamber for the exposure of plants to air pollutants in the field. J. Environ. Quality, 2, 371.

Thomas, M.D. and Hendricks, R.H. (1956) Effect of air pollution on plants. IN: Magill, P.L., Holder, H.R. and Ackley, C. Air Pollution Handbook. New York, McGraw Hill., 19.

Thomas, M.D. and Hill, G.R. (1935) Absorption of sulphur dioxide by alfalfa and its relation to leaf injury. Plant Physiol., 10, 291.

Weatherley, M-L.P.M., Gooriah, B.D. and Charnock, J. (1975). Smoke and sulphur dioxide emissions and concentrations and grit and dust deposition in the United Kingdom, up to 1973/74. Warren Spring Laboratory Standing Conference of Co-operating Bodies; Investigation of air pollution SCCB 85/6.

Wellburn, A.R., Majernik, O. and Wellburn, F.A.M. (1972 Effects of sulphur dioxide and nitrogen dioxide polluted air upon the ultrastructure of chloroplasts. Environ. Pollut. 3, 37.

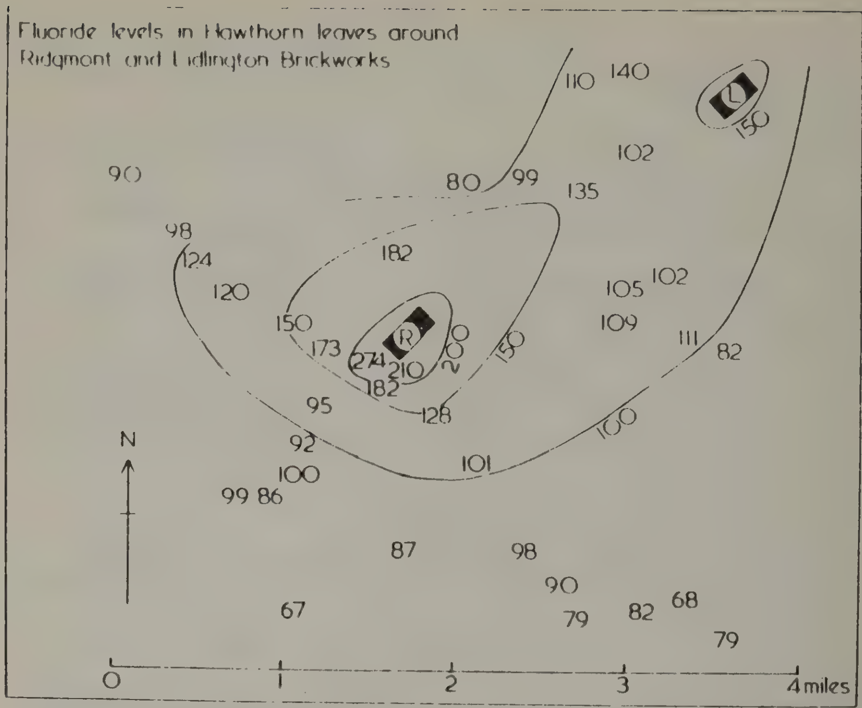


FIG. 1: The concentration of fluoride (p.p.m.) in leaves collected from hawthorn hedges around the Ridgmont works.

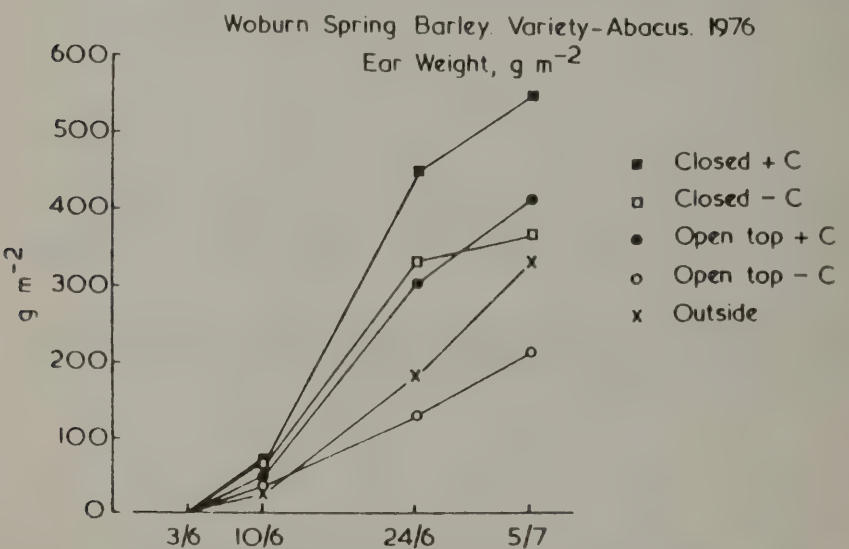


FIG. 2: Yield of spring barley, var. Abacus, at Woburn experimental farm 2 km south west of Ridgmont works. Plants were grown in two types of chamber with or without filtration or ambient air and in the open field.

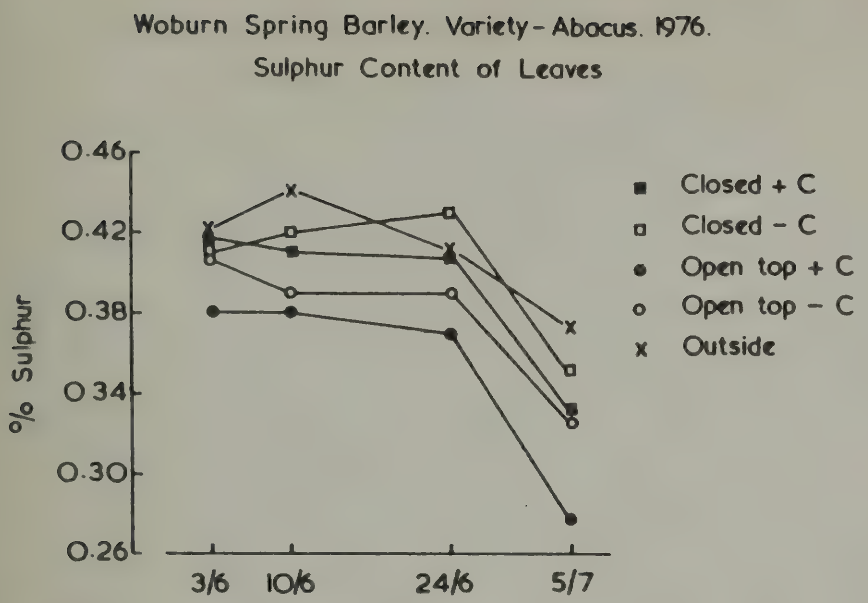


FIG. 3: The sulphur content of leaves.

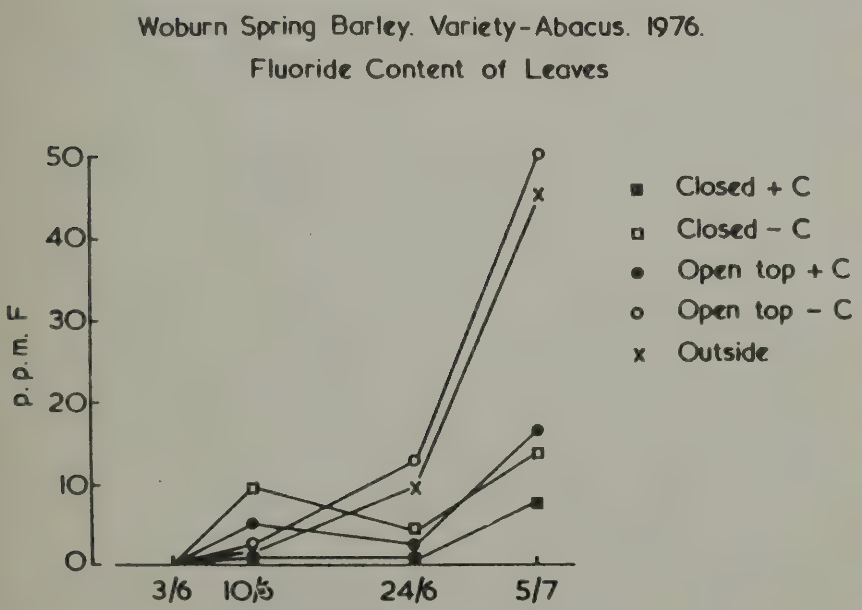


FIG 4: The fluoride content of leaves.

NATIONAL SOCIETY FOR CLEAN AIR

44th CLEAN AIR CONFERENCE

SEPTEMBER 19 - 22, 1977

HARROGATE

EFFECTS OF ATMOSPHERIC POLLUTANTS ON FORESTS AND NATURAL PLANT ASSEMBLAGES

Professor F.T. Last
NERC, Institute of Terrestrial Ecology

136 North Street
Brighton BN1 1RG
England

Instead of giving a general review I have decided to focus intensively on two aspects, namely, (a) the ways in which natural populations of plants respond when exposed to one of a variety of pollutants and (b) the recent changes in our approach to the sulphur problem particularly as they apply to forests.

Forests: the changing emphasis in the sulphur problem

Had this Conference been held thirty or more years ago my task would have been relatively simple. Having introduced you to the differing types of pollutants I would then have proceeded to focus on the most notable, discussing the effects of sulphur in terms of sulphur dioxide (SO_2) released when burning fossil fuels for the generation of power, smelting/refining, domestic heating .... Since then, however, environmental awareness and scientific understanding have intensified.

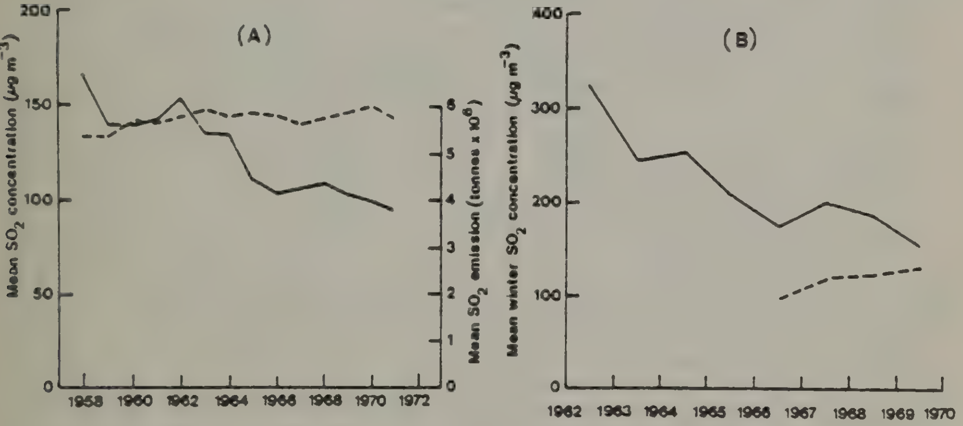


Fig 1.(A) Sulphur dioxide emissions (---) and mean urban concentrations (——) in the U.K. in the period 1958 – 1971 (Anon, 1974)

(B) Mean winter concentrations of SO_2 in urban (——) and rural (---) areas of North-west England. (Anon, 1972)

Although amounts of smoke decreased by 65% in the period 1956–71, the Clean Air Acts of 1956 and 1968 have not, on balance, greatly decreased the U.K. annual emissions of SO_2 which are c. 6 x 10^6 tonnes. Significantly however, ground-level concentrations of this gas have decreased by 30% in urban areas of the U.K. (Chamberlain and Penkett, 1972) an effect suggesting that more sulphur pollutant is widely dispersed than hitherto (Fig. 1). This change, also noted in the Netherlands, is attributed to at least four factors:

(a) With decreasing amounts of smoke since the enforcement of the Clean Air Acts, sunshine hours have increased and temperature inversions have been less persistent,
(b) pollutants from a number of major sources have been released into the atmosphere at greater heights with the introduction of taller stacks

(chimneys),
(c) there have been fewer periods of stagnant winter weather, and increased turbulence.

SO_2 can be oxidised to sulphuric acid by a variety of gas and liq[illegible] reactions and, for a variety of reasons, the quantities of partic[illegible] increase in relative abundance with increasing distances from sources of emission. Essentially the further a 'sulphur-cloud' is from its point of emission the older it is, and therefore the greater the probability of the transformation from SO_2 to SO_4 having occurred. Secondly, whereas the rate of deposition of particulate SO_4 from dry atmospheres is trivial (10^{-2} to 10^{-4} cm s^{-1} (Garland, 1974)), concentrations of SO_2 are depleted relatively rapidly (c. 0.7 cm s^{-1}) by 'dry deposition', a term including the absortion of SO_2 by plants, soil and water.

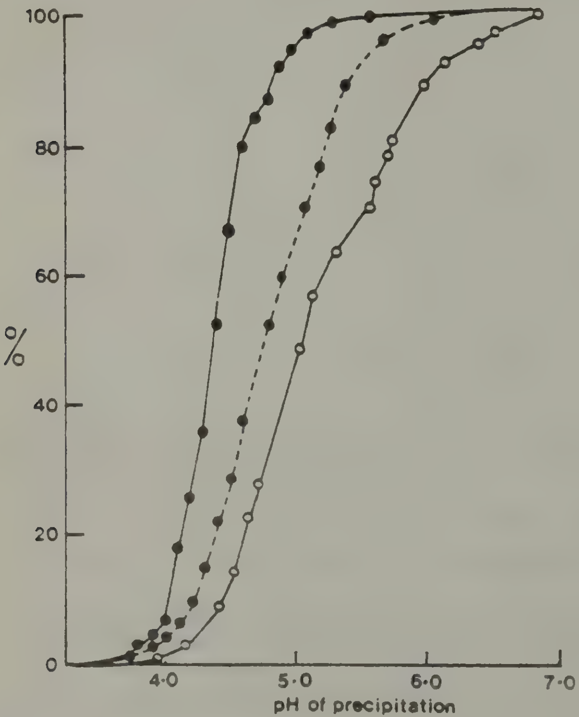


Fig 2. Percentages of rain showers with pHs lower than a given value at three locations in Norway during the period July 1972 to June 1975. (Dovland et al., 1976)
(●—● Birkenes; ●- - -● Fitjar; ○—○ Tagmyra)

Whereas the atmospheric load of sulphur is depleted of its [illegible] component by dry deposition, rain is required for the efficient removal of [illegible] SO_4, 'wet deposition' (Fig. 2). Johansson (1959) [illegible]

times as much sulphur was removed by dry deposition as by wet deposition near an emission source in Sweden whereas, 24km distant, the ratio was down to 2:1. In the U.K. the ratios are thought to be 6:1 and 1:1 in urban and remote rural areas respectively (Anon, 1976), but this is not to suggest that dry deposition of SO_2 is without significance in rural areas.

Thus we havecome to recognize that two differing sets of conditions can be attributed to sulphur pollution (a) those near to sources of emission which are dominated by gaseous SO_2 and (b) those at a distance where SO_4, and hence acid precipitation, is of greater significance.

Although badly informed about what happens to trees when growing near sources of sulphur pollutants, we know even less of the effects of acid precipitation in rural areas where most forests occur. Curiously, our ideas about threshold concentrations of SO_2 needed to cause damage have progressively changed during the twentieth century. "About 1900 and some time later, it was believed that about 5720 $\mu g\ m^{-3}$ was the (lower) limit at which damage might occur. About 1950, the threshold value was considered to be c. 570 $\mu g\ m^{-3}$ but now, 20 years later, it is more likely to be c. 57 $\mu g\ m^{-3}$ if measured as an arithmetic mean value (1pphm SO_2 = 28.6 $\mu g\ m^{-3}$). It is still not possible to determine a threshold value below which no damage may occur." (Tamm and Aronsson, 1972).

It is not altogether easy to account for this downward trend doubtless attributable in part to more reliable analyses and to greater dependence in recent years on more expertly implemented series of objective experiments. In fact we are only just beginning to appreciate the full interplay between sulphur and other pollutants. Substances such as oxides of nitrogen and hydrocarbons (Renzetti and Doyle, 1960) and ozone (Kellog et al., 1972) are sometimes involved in the photochemical oxidation of SO_2 whereas on other occasions they act synergistically and accentuate the damage done to plants by SO_2. Tingey et al. (1971) found that mixtures of SO_2 and NO_2 each at concentrations of less than 25 pphm caused substantially more damage than the sum of their separate effects: in other words there was a synergistic effect which has subsequently been confirmed by Wellburn et al. (1976). Dochinger and Heck (1969) and Dochinger et al. (1970) found that SO_2 and O_3 interacted synergistically stimulating the development of chlorotic dwarf in eastern white pine, Pinus strobus, a syndrome including needle mottling and premature defoliation. In another set of circumstances Williams and his colleagues (1971) working in South Wales with sessile oak (Quercus petraea) found, in conditions where concentrations of dust but not of SO_2 varied spatially, that leaf sulphur concentrations were directly proportional to numbers of stomata plugged with particles and therefore unable to close (Fig. 3).

In the pollution literature there are many observations that are difficult to reconcile, I suspect because of inadequate environmental characterisations. Recently Ashenden and Mansfield (1977) have highlighted the importance of at least some wind movement. When fumigated with atmospheres containing 315 $\mu g\ m^{-3}$ (= 11 pphm) and circulating at 25 m min^{-1} the growth of perennial ryegrass Lolium perenne was significantly decreased: at a wind speed of 10 m min^{-1} growth remained unaffected. Loftfield, as early as 1921, suggested that stomata play an important role in the uptake of SO_2

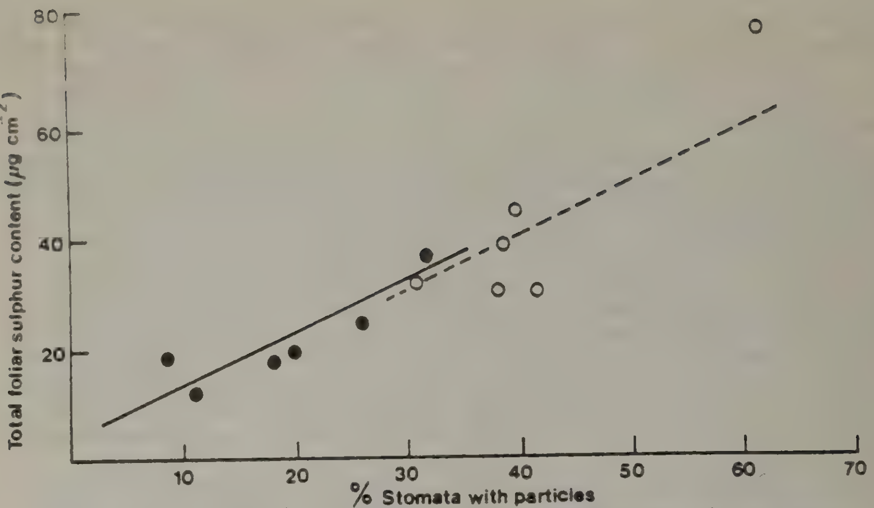


Fig.3 Relation between % stomata blocked, or partially blocked, with particulate matter and the total sulphur content of leaves of Quercus petraea growing in S.Wales Williams et al., 1971 (Observations made on 4th June (●) and 16th August (○) 1969.)

which, however, must first transfer from the general atmosphere to the boundary layer of individual leaves, the resistance to this transfer being large in still conditions.

Notwithstanding the doubts cast by our increasing awareness of a variety of interactions, also our inability to interpret effects of SO_2 measured during prolonged 'laboratory' exposures at constant concentrations in terms of diurnally, weekly and monthly changing conditions in the field, it is still possible to make some broad generalisations.

From observations collated from many parts of the world Bytnerowicz and Molski (1974) tabulated trees that are either tolerant or susceptible to fumes, the effects of which were attributed to SO_2.

(a) Tolerant

Acer negundo - Ash-leaved maple/Box elder.
Alnus glutinosa - Common alder.
Pinus nigra var. nigra - Austrian pine.
Populus spp. - Poplars.
Quercus petraea - Sessile oak.
Robinia pseudoacacia - False acacia/Black locust
Salix caprea - Goat Willow
Sambucus sp. including S. pubens a native of N. America
Taxus baccata - Yew.

(b) Susceptible

Acer platanoides - Norway maple.
Aesculus hippocastanum - Horse chestnut.
Betula pendula - Silver birch.
Corylus avellana - Hazel.

Larix kaempferi - Japanese larch.
Picea abies - Norway spruce.
Pinus spp. including P. ponderosa - Western yellow pine.
P. Strobus - Weymouth or Eastern white pine;
P. sylvestris - Scots pine.
Prunus avium - Gean/Wild Cherry.
Sorbus aucuparia - Rowan.
Tilia spp. - Lime.

From British experience I'm sure that the London plane (Platanus x hispanica) should also be added to the list of tolerant types.

Typically, damage to conifers first shows as needle necrosis followed by premature leaf fall, needles dropping at the end of their first season instead of being retained for 3 or more years (Lizon, 1972). In Czechoslovakia, Norway spruce was conspicuously damage when atmospheric concentrations of SO_2 averaged 170 $\mu g\ m^{-3}$ with occasional half-hourly peaks exceeding 570 $\mu g\ m^{-3}$ Knabe (1970) came to the conclusion that it was pointless to plant spruces and pines. In other experiments done in Switzerland, Keller (1976) found that Norway spruce showed conspicuous needle damage after 6 months' continuous exposure to c. 570 ug SO_2 m^{-3}, whereas none appeared for at least nine months at 140 and 286 $\mu g\ m^{-3}$. In the U.K. Professor Rutter of Imperial College has recently found that the growth of Scots pine and sycamore (Acer pseudoplatanus) were decreased by c. 20% when continually exposed to 150 $\mu g\ m^{-3}$ whereas that of birch and oak seemed unaffected.

Table 1. Monthly average, and largest daily, concentrations of atmospheric SO_2 at selected sites in four cities during July and November 1973.

	SO_2 concentrations $\mu g\ m^{-3}$			
	July		November	
	Monthly average	Highest daily	Monthly average	Highest daily
London	131	296	303	674
Manchester	107	170	223	708
Newcastle-upon-Tyne	132	300	357	684
Glasgow	72	112	218	659

But what do all these observations mean in terms of British forestry? Clearly amenity trees are at risk in some urban areas where monthly average concentrations of SO_2 exceed 200 $\mu g\ m^{-3}$ (Table 1) (cf. the absence of Scots

pine from the Manchester/Leeds conurbation (Rutter, personal communication)). But, most of our managed woodlands and forests are in rural areas where annual mean concentrations of SO_2 only reach 35-40 $\mu g\ m^{-3}$. Undoubtedly it has, in the past, been difficult to establish vigorous plantings in parts of the Pennines and South Wales but even in these areas growth seems to have noticeably improved in recent years. On balance, and with our present knowledge, it therefore seems that ambient concentrations of SO_2 experienced in rural areas are unlikely to directly affect tree growth unless future research shows that these small mean concentrations obscure the possible occurrence of damaging ephemeral exposures to much higher concentrations - there has been no suggestion that trees in the U.K. would have suffered sulphur deficiencies in the absence of continuing inputs of sulphur pollutants.

If amounts of gaseous sulphur pollutants occuring in the U.K. are unlikely to be directly damaging to our predominantly rural woodlands and forests what about particulate forms? As already mentioned particulate SO_4 is relatively more important in rural situations and is efficiently scrubbed from the atmosphere by rain. Together with other strong acids, notably nitric acid, it gives rise to acid precipitation - a phenomenon of great concern to ecologists who until now have paid little attention to the work of Gorham published in 1958. The degree of acidity reflects the concentration of hydrogen ions(H^+) remaining when acids are not completely neutralized. Remembering that uncontaminated rain, if such a thing existed, would have a pH of c.5.6 when in equilibrium with atmospheric carbon dioxide (CO_2), then the amount of acidity can be judged by deviations from this value. In the period from 1962 and 1973 the pH of rainfall samples collected in rural Scotland have shown a trend towards increasing acidity (Table 2), a trend that has been paralleled in the U.S.A. (Cogbill and Likens,1974) and southern Scandinavia (Oden, 1976) where pH values of 3.9 - 4.4 are not uncommon.

Table 2. The acidity (pH) of rainfall samples collected in 1962, 1973 or 1974 at five rural locations in Scotland (Anon, 1976).

	Faskally	Shelligan	Strath Bran	Loch Leven	Loch Ard
1962	5.1	4.7	5.2	-	-
1973	4.2	4.2	4.6	4.6	4.2
1974	4.2	4.2	-	4.6	4.2

Strong acids are well known to damage plants vide the use of sulphuric acid for killing potato haulms prior to harvesting. However, it should be remembered that the differing components of 'natural' acid precipitation may be having opposite effects - the damage done by acidity per se being offset by the nutrient value of nitrogenous substances - the nutrient value of sulphur pollutants to trees having already been discounted.

In a series of controlled experiments, simulated acid rain has

(a) accelerated the erosion of leaf cuticle (Shriner, 1976),
(b) decreased, in some instances, the incidence of leaf pathogens e.g. Cronartium fusiforme on oak (Quercus phellos), and
(c) induced leaf necroses in birch, Betula pubescens, and Scots pine at pH 2.0 - 2.5 (Abrahamsen et al., 1976).

Additionally, it have been conjectured that acid may affect growth by interfering with the normal functioning of guard cells and other leaf tissues, by accelerating the exudation of leaf leachates and altering symbiotic associations (Tamm and Cowling, 1976). Notwithstanding these actual and possible effects, it has not yet been possible to obtain unequivocal evidence of yield losses in the 'field'. In preparation for the United Nations Conference on the Human Environment held in Sweden in 1971, Jonsson and Sundberg (1972) classified areas in southern Sweden by soil characteristics identifying types that were either tolerant or susceptible to the effects of acid rain. They then analysed the historical record of annual increments in Norway spruce and Scots pine and suggested that growth was significantly less on the susceptible soils than on the tolerant, at the same time indicating that they could find "no good reason for attributing the reduction in growth to any cause other than acidification". These results were the basis of a claim in Sweden's case study presented to the U.N. Conference, that acid precipitation was decreasing the annual growth of trees in southern Sweden by c. 0.3% implying that, by the year 2000, acid precipitation might have decreased growth by a total of 10 - 15%. However, by 1976 Tamm, also of Sweden, had concluded that deleterious effects on forest growth had not yet been substantiated so agreeing with Abrahamsen et al. (1976) in Norway, and Cogbill (1976) of the U.S.A. who also depended upon historical analyses of tree-rings. Contrarywise, Abrahamsen et al. (1976) increased the height of young specimens of lodgepole pine (Pinus contorta) during a 3-year period of regularly applying simulated acid precipitation (at either pH3 or 4) to field plots.

At present, therefore, there is no good evidence to suggest that sulphur pollutants are deleteriously affecting the incremental growth of trees in rural areas. But, it should be remembered that these areas of the U.K. and southern Norway, are annually receiving 10 - 25 kgS/ ha. yr. as a result of wet (acid precipitation) and dry deposition (Anon, 1976). Complacency would be inexcusable. We should be greatly concerned with the fate of the incoming sulphur. Is it affecting growth, but for the time being at a level below the limits of statistical detection? Could it in the long term dangerously acidify soils, with consequent effects on growth, a thought prompted by the widely accepted direct relation between forest yields and soil base status which can be expressed in many ways including base saturation percentage, concentration of exchangeable ions or pH (see Dahl and Skre, 1971).

The effects of acid precipitation on soils should not be considered in isolation remembering that forest soils in north-west Europe naturally tend to be acidic (podsolized) because they are formed above igneous, metamorphic or non-calcareous parent materials (which are base deficient)

in high rainfall areas where leaching is commonplace (see Jenny, 1941). Further, the process of acidification is accentuated by the acid humus formed by conifers. On theoretical grounds it would be expected that acid precipitation would least affect acid soils pH<5, but strongly influence those with pH>5. The former soils are strongly buffered and their acidity is close to that of acid precipitation - it is suggested that the effects of rainfall might prove to be trivial compared with those of acids (chelating) released from coniferous humus (Bache, 1977). On the nearer neutral predominantly agricultural soils (pH>5), to which lime is regularly applied, acid precipitation might be more damaging but how would this effect compare with the acidifying effects of many nitrogenous fertilisers? In this instance pollutant sulphur might usefully help minimise sulphur deficiencies.

But these deductions are largely speculative. It is essential to thoroughly understand the pathway of sulphur through a forest ecosystem - the movement and transfer of sulphur from the atmosphere through a forest canopy, to the understory thence to soil. Bjor and his colleagues (1974) have already hinted that stemflow and throughfall collected beneath Scots pines tends to be more acidic than those under birch. They found c. 3,350 and 1,530 mg $SO_4 m^{-2}$ in throughfall and 20.3 and 15.0 mg SO_4 1^{-1} in stem-flow associated with Scots pine and birch respectively. The stemflow data have in part been corroborated by foliar and bark analyses done by colleagues in the Institute of Terrestrial Ecology. They found that

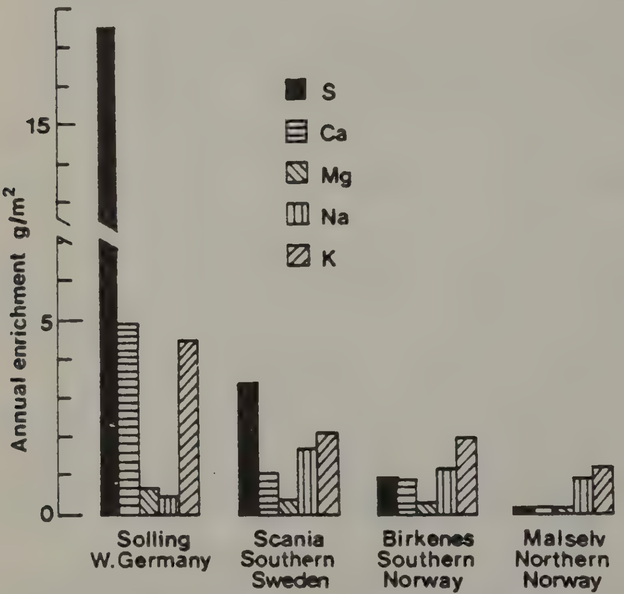


Fig 4. Annual enrichment of rain passing through the canopies of Norway spruce growing in four differently polluted localities of Europe.

(*Malmer*, 1976)

significantly more SO_4 could be washed from the bark of Scots pine than from birch (Nicholson et al. 1977). How important is such an effect (see Fig. 4) and on what kind of timescale, remembering that the increased acidity may deleteriously affect microbes forming beneficial mycorrhiza (a relation between tree roots and a group of symbiotic fungi); it may decrease nitrogen mineralization also increase rates at which minerals are leached from soil.

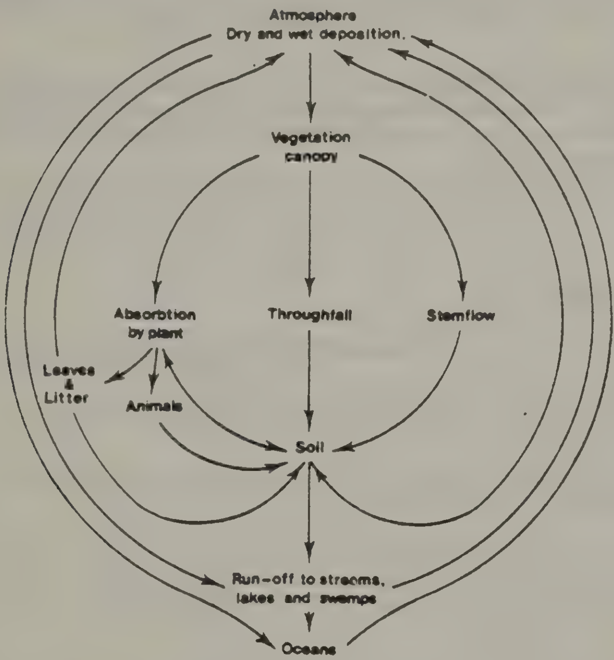


Fig 5. The main pathways in the sulphur cycle with special reference to woodland ecosystems.
(Nicholson et al., 1977)

Clearly the problem of sulphur pollution is complex. There are many unknowns but one fact is difficult to dispute, namely, forest soils annually receive a total of c. 10 - 20 kg S/ha by dry and wet deposition (from airborne loads). The Institute of Terrestrial Ecology with colleagues in other Institutes and in many Universities, is taking part in a collaborative exercise aiming to characterize the movement of sulphur through forest ecosystems recognizing that events in soil may influence run-off and drainage to bodies of freshwater (Fig. 5), so affecting course and game fisheries - but this is another story.

NATURAL COMMUNITIES: POPULATION CHANGES

In discussing crop damage done by pollutants it is customary to consider

two types of injury (a) acute, where tissues become chlorotic or where cells are immediately and obviously killed with the development of necroses (Heggestad and Heck, 1971) and (b) chronic, when growth is retarded often with premature leaf fall (van Haut and Stratmann, 1970). For natural ecosystems however it is possibly more appropriate to consider effects in terms of population changes, a sorting of different plant species within an assemblage and/or of genotypes within a species. For this Conference I am being intentionally insular, using examples recorded in the U.K.

Table 3. Assemblages of corticolous lichens found on moderately acid bark (oak) of trees growing in parts of England and Wales with different winter concentrations of atmospheric SO_2 (Hawksworth and Rose, 1976).

Zone		Mean winter SO_2 ($\mu g/m^3$)
0	Epiphytes absent	?
1	Pleurococcus viridis s.l. present but confined to the base	>170
2	Pleurococcus viridis s.l. extends up the trunk; Lecanora conizaeoides present but confined to the bases	about 150
3	Lecanora conzaeoides extends up the trunk; Lepraria incana becomes frequent on the bases	about 125
4	Hypogymnia physodes and/or Parmelia saxatilis, or P. sulcata appear on the bases but do not extend up the trunks. Lecidea scalaris, Lecanora expallens and Chaenotheca ferruginea often present	about 70
5	Hypogymnia physodes or P. saxatalis extends up the trunk to 2.5 m or more; P. glabratula, P. subrudecta, Parmeliopsis ambigua and Lecanora chlarotera appear; Calicium viride, Lepraria candelaris and Pertusaria amara may occur; Ramalina farinacea and Evernia prunastri if present largely confined to the bases; Platismatia glauca may be present on horizontal branches	about 60
6	P. caperata present at least on the base; rich in species of Pertusaria (e.g. P. albescens, P. hymenea) and Parmelia (e.g. P. revoluta (except in NE), P. tiliacea, P. exasperatula (in N); Graphis elegans appearing; Pseudevernia furfuracea and Alectoria fuscescens present in upland areas	about 50
7	Parmelia caperata, P. revoluta (except in NE), P. tiliacea, P. exasperatula(in N) extend up the trunk; Usnea subfloridana, Pertusaria hemisphaerica, Rinodina roboris (in S) and Arthonia impolita (in E) appear	about 40

8	Usnea ceratina, Parmelia perlata or P. reticulata (S and W) appear; Rinodina roboris extends up the trunk (in S); Normandina pulchella and U. rubiginea (in S) usually present	about 35
9	Lobaria pulmonaria, L. amplissima, Pachyphiale cornea, Dimerella lutea, or Usnea florida present; if these absent crustose flora well developed with often more than 25 species on larger well lit trees	under 30
10	L. amplissima, L. scrobiculata, Sticta limbata, Pannaria spp., Usnea articulata, U. filipendulla or Teloschistes flavicans present to locally abundant	'Pure'

Table 4. Lichen assemblages associated with different amounts of smoke and atmopheric SO_2 in England and Wales (Hawksworth and Rose, 1976)

Localities	Lichen assemblages (see Table 3 for 'zones')	Mean winter (1967-70) concentrations, $\mu g/m^3$ SO_2	smoke
Leicester	0-1	175	89
Kew	2-3	150	38
Buxton	3	126	17
Sheffield	3	88	43
Dursley	3-4	87	22
Hayfield	3-4	84	102
Plymouth	3-4	82	97
Prestwood	6	60	32
Didcot	7	39	22
Torquay	8	32	33
Llanberis	9	27	29

For many years lichenologists have been assembling evidence strongly incriminating aerially dispersed pollutants - perhaps more has been deduced about the effects of these substances on lichens than on higher, flowering plants. In surveys done in England and Wales since 1967, appreciably fewer lichen species have been found near major conurbations and centres of industry than elsewhere (see Fig. 6 and note smaller numbers in the London area and northwards through the Midlands). Although effects on environ-

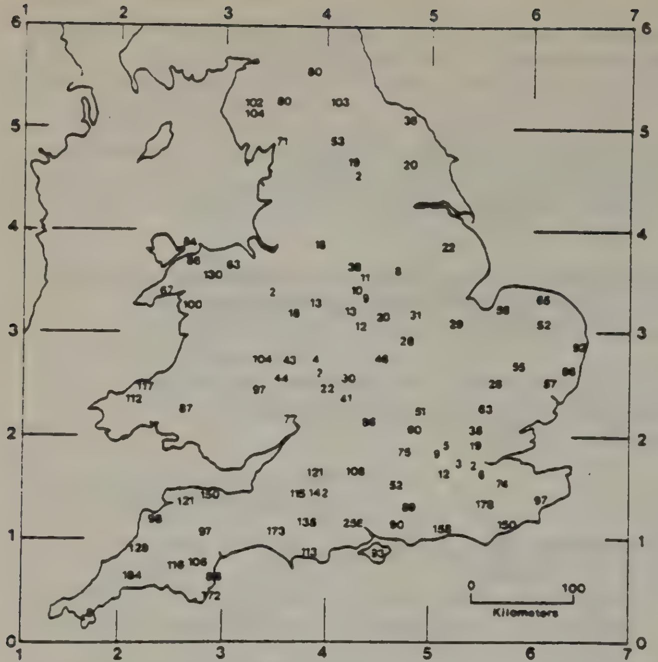


Fig 6. Numbers of corticolous lichen species recorded since 1967 in selected woodland and parkland sites in England and Wales.
(*Hawksworth and Rose, 1976*)

mental variables such as temperature and humidity should not be ignored, Hawksworth and Rose (1976), following the lead given by Dr. O.L. Gilbert, have associated the fewer lichen species with increased mean winter atmospheric concentrations of SO_2 ($\mu g/m^3$) particularly as there seems little or no immediately obvious connection with amounts of smoke (Table 4). Hawksworth and Rose defined ten zones where different assemblages of lichens and the algal Pleurococcus viridis are associated with different amounts of atmospheric SO_2, a scheme implying that some lichens are more tolerant than others, of the direct and indirect effects of this pollutant. Thus zone 2, with SO_2 concentrations of c. 150 $\mu g/m^3$, is characterized by the tolerant Pleurococcus viridis and Lecanora conzaeoides and L. expallens whereas zone 8 with c. 35 μg SO_2/m^3 has an array including the sensitive Usnea ceratina, Parmelia perlata and Parmelia reticulata (Table 3). Further, their scheme has been modified to accommodate the different lichen assemblages colonizing trees with (a) moderately acid bark (e.g. oak) and (b) basic or nutrient enriched bark (e.g. elm).

When comparing records made in the period 1850-1890 with those assembled since the formation of the British Lichen Society in 1958, it seems that many lichen species are now less widely distributed then heretofore, e.g. those of Usnea spp., whereas the pollutant tolerant Lecanora conizaeoides has greatly extended its range - an effect of industrialisation.

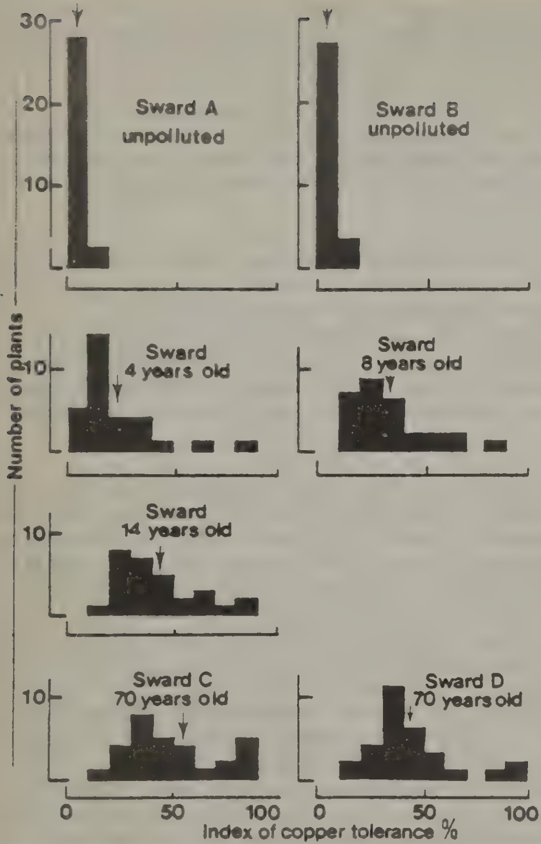


Fig 7. The occurrence of copper tolerance in swards of different ages around a copper refinery near Liverpool.
(Bradshaw, 1976)

Decreasing species diversity is a characteristic of polluted environmments. This is true not only for the effects of sulphur pollutants on lichens but also for the effects of this and others on flowering plants. In swards affected by copper, aerially dispersed from a refinery, numbers of species of flowering plants rapidly decreased from c. 50 to 2. The survivors, in a series of lawns, were specimens of Agrostis tenuis and Agrostis stolonifera, two of at least twenty species known in different parts of the world, to be metal tolerant (Atonovics et al., 1971). Whereas the young lawns around the refinery had scattered plants with appreciable intervening bare areas the older lawns have a complete cover of Agrostis tenuis and Agrostis stolonifera (Wu et al. 1975). Subsequent critical toxicity tests with specimens of these 2 species indicated that there was a progressive build-up of copper tolerance with the elimination of non-tolerant types, the population at 10 to 15 years giving a satisfactory lawn (Fig. 7). An

examination of large populations of *A. tenuis* indicated that tolerance had not evolved de novo but existed in a very small proportion of plants growing in unpolluted areas. It seems therefore that pollutants can exert very strong selection pressures and in so doing they may locally change at least one facet of the genetical make-up of a species, (other facets remain varied as shown by isoenzyme analyses (Wu et al., 1975)). In some instances the pressures may be extreme selecting types wholly dependent upon appreciable amounts of heavy-metal e.g. some populations of *Armeria maritima* and zinc (see Antonovics et al., 1971).

Tolerant genotypes are fitted for polluted conditions but how do they react to competition from others in unpolluted areas? The work of Hickey and McNeilly (1974) using metal-tolerant specimens fo *Agrostis tenuis*, *Anthoxanthum odoratum*, *Plantago lanceolata* and *Rumex acetosa* in competition with 'normal' *Lolium perenne*, suggests that they would not be successful. In the absence of pollutants, natural forces select against tolerance which is also likely to be diminished by inadvertent (natural) crosses with non-tolerant stocks.

In addition to being found in flowering plants, metal tolerance has been detected among mosses and liverworts, Briggs (1972) having isolated colonies of the liverwort *Marchantia polymorpha* from four sites (including three with concentrations of soil lead exceeding 400 ppm and a fourth, the 'control' with less than 30 ppm) found that they all grew equally well on media without lead, the addition of which did not deleteriously affect the growth of isolates from the three polluted sites; in contrast the growth of the control isolate was significantly decreased.

Knowing the ability of different plant species to respond individually to pollutants it might become possible to predict the responses of communities. However, it is more immediately important to question whether tolerance can be usefully exploited. I have already referred to heavy-metal tolerance but now wish to turn to events in the Helmshore area of Lancashire (Bell and Mudd, 1976) where natural swards of *Lolium perenne*

Table 5. Shoot dry weights (g) of S23 and Helmshore *Lolium perenne* grown for 9 weeks in atmospheres with different concentrations of SO_2 (Bell and Mudd, 1976).

Type of *L. perenne*	Concentrations of SO_2 ($\mu g\ m^{-3}$)	
	14	343
S23	0.30 ±0.024	0.50 ±0.019
Helmshore	0.54 ±0.075	0.54 ±0.065

Table 6. Effects of 26 weeks fumigation with SO_2 on the chlorophyll contents ($\mu g\ cm^{-2}$) of sensitive (S23) and tolerant (Helmshore) strains of *Lolium perenne* (Bell and Mudd, 1976).

(a) Chlorophyll a		
S23	24.1±1.88	18.5±1.22
Helmshore	21.8±3.26	23.4±1.63
(b) Chlorophyll b		
S23	9.2±0.60	6.7±0.38
Helmshore	9.3±1.56	8.7±0.52
(c) Total chlorophyll		
S23	33.3±2.45	25.3±1.56
Helmshore	31.0±4.74	32.1±2.09

were found to be more continuously productive than those of the improved varieties S23 and S24. Subsequently, controlled experiments have shown that strains from Helmshore, subject to aerial pollution since the time of the Industrial Revolution, are SO_2 tolerant. Whereas they grew equally well in atmospheres with and without SO_2, the growth of the commercial S23, although the same as the Helmshore strain in the untreated controls was halved when continuously exposed to 191 or 343 $\mu g\ SO_2/m^3$. The Helmshore plants were healthily green after being exposed to SO_2 for 9 or 26 weeks, whereas those of S23 were chlorotic (Table 5). Until now little is known of tolerence-mechanisms but preliminary observations suggest that SO_2 is not excluded from foliage; instead it is internally prevented from degrading chlorophy11 (Table 6). Coincidentally copper tolerance is not attributed to its rejection (exclusion) by roots of Agrostis stolonifera.

In this instance it seems that copper is accumulated in the roots of tolerant specimens but exported to the foliage in sensitive types (Wu et al., 1975)

Although this paper is primarily concerned with plants, the interdependence of plants and animals should not be ignored particularly as pollutants, by affecting lichens, may also affect some invertebrates albeit the connections are tenuous. Since Kettlewell's paper published in 1956 much has been written about melanism which was first noted in the mid-nineteenth century. The upsurge in melanism seems to be related to events following the Industrial Revolution. In the late 1960's the 'carbonaria' morph formed c. 87% of the Birmingham population of the peppered moth, Biston betularia. Whereas the development of melanic forms of the two spotted ladybird Adalia bipunctata is related to amounts of smoke those of Betularia are

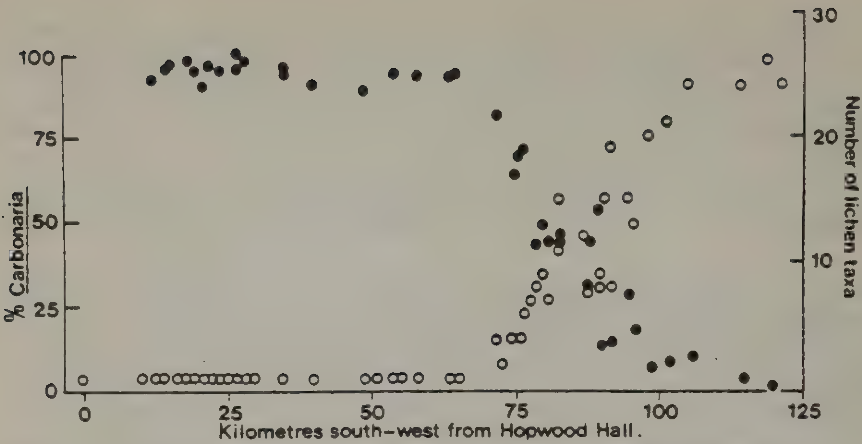


Fig 8. Frequency of the carbonaria form of the peppered moth Biston betularia (•) and numbers of lichen taxa (O) along a S.W. transect of decreasing SO_2 and smoke pollution from Hopwood Hall c. 10 km north of Manchester.
(*Bishop et al*, *1975*)

associated with mean winter concentrations of SO_2 - the higher the SO_2 concentrations the greater the proportion of melanic forms. On making a detailed analysis it was found that the abundance of the carbonaria morphs of B. betularia was directly related to the occurrence of tree trunks blackened with soot and without epiphytic lichens (Fig. 8), the logical consequence of heavy winter pollution (Bishop et al., 1975). Further, in experiments done with their avian predators the melanic camouflage gave the carbonaria forms a 6:1 survival advantage over the usual light coloured forms in polluted areas - the opposite being true in unpolluted areas where the light coloured forms blended more readily with the cover of epiphytic lichens and were therefore less readily taken by birds. The selection of melanic forms, as a result of pollution, enables a number of species to conceal their presence and so minimize the risks of predation. As with pollution tolerance in plants, where tolerant individuals can be found in unexposed populations, melanic moths occur in ordinary populations of the same moth. Because they are conspicuous against a background of lichens, they are ready victims of predation. Interestingly the ratio of melanic: light coloured forms of Biston betularia, has recently decreased in Liverpool changing from 94.8% in 1961 to 89.5% in 1974 - possibly a consequence of the enforcement of smokeless zones (Bishop and Cook, 1975).

In concluding I am reminded of a statement made in 1972 by your Secretary General, Rear-Admiral P.G. Sharp (of the National Society for Clean Air) - "Make certain before any action is undertaken to alleviate a particular type of pollution that the consequences as they affect the whole of the environment are known". I suspect that my examples will have convinced you that this is impossible.

REFERENCES

ABRAHAMSEN, G., BJOR, K., HORNTVEDT, R. and TVEITE, B. (1976). Effects of acid precipitation coniferous forest. In Impact of acid precipitation on forest and freshwater ecosystems in Norway. Ed. F.H. Brœkke: SNSF-Project, NISK,1432 Aas-NLH,Norway, pp. 37-63.

ANON. (1972). National survey of air pollution 1961-1971. Vol. 2, South West Region, North Wales Region, North West Region. London, Her Majesty's Stationery Office.

ANON. (1974). Clean air today. London, Her Majesty's Stationery Office.

ANON. (1976). Effects of airborne sulphur compounds on forests and freshwaters. A report of the discussion group of the Department of the Environment and the Natural Environment Research Council. H.M.S.O. Pollution paper no. 7. 28pp.

ANTONOVICS, J., BRADSHAW, A.D. and TURNER, R.G. (1971). Heavy metal tolerance in plants. Adv. Ecol. Res., 7, 1.85.

ASHENDEN, T.W. and MANSFIELD, T.A. (1977). Influence of wind speed on the sensitivity of ryegrass to SO_2. J. exp. Bot., 28, 729 - 35.

BACHE, B.W. (1977). Personal communication.

BELL, J.N.B. and MUDD, C.H. (1976). Sulphur dioxide resistance in plants: a case study of Lolium perenne. In Effects of air pollutants on plants, pp. 87-103 Ed. T.A. Mansfield. University Press: Cambridge.

BISHOP, J.A. & COOK, L.M. (1975). Moths, melanism and clean air. Scient. Am., 232, 90-9.

BISHOP, J.A., COOK, L.M. MUGGLETON, J. and SEAWARD, M.R.D. (1975). Moths, lichens and air pollution along a transect from Manchester to North Wales. J. appl. Ecol., 12, 83-98.

BJOR, K., HORNVEDT, R. & JORANGER, E. (1974). Distribution and chemical composition of precipitation in a southern Norway Forest stand. Norwegian Council for Scientific and Industrial Research Rep. 1/74.

BRADSHAW, A.D. (1976). Pollution and evolution. In Effects of air pollutants on plants, pp. 135-59. Ed. T.A. Mansfield. University Press: Cambridge.

BRIGGS, D. (1972). Population differentiation in Marchantia polymorphal in various lead pollution levels. Nature, Lond., 238, 166-7.

BYTNEROWICZ, A. and MOLSKI, B. (1974). Wplyw Atmosferycznego Dwutlenku Siarki na Roslinnose. Wiad. bot., 18, 169-82.

CHAMBERLAIN, A.C. and PENKETT, S.A. (1972). Atmospheric Pollution and present trends and future problems. Contemp. Phys. 13, 179-98.

COGBILL, C.V. (1976). The effect of acid precipitation on tree growth in eastern North America. In Proceedings of the first international symposium on acid precipitation and the forest ecosystem. Ohio, 1975. pp. 1027-32 USDA Forest service general technical report NE-23.

COGBILL, C.V. and LIKENS, G.E. (1974). Acid precipitation in the northeastern United States. Wat. Resour. Res. 10, 1133-7.

DAHL, E. and SKRE, O. (1971). En undersøkelse over virkningen av sur nedbør pa produktiviteten: landbruket. Konferens om avsvavling, Stocklholm 11 Nov. 1969. Nordforsk Miljovards-sekreteriatet: 1, 27-39.

DOCHINGER, L.S., BENDER, F.W., FOX, F.L. and HICK, W.W. (1970). Chlorotic dwarf of Eastern White Pine caused by an ozone and sulphur dioxide interaction. Nature, Lond., 225, 476.

DOCHINGER, L.S. and HECK, W.W. (1969). On ozone-sulphur dioxide synergism produces symptoms of chlorotic dwarf disease of eastern white pine. Phytopathology, 59, 399.

DOVLAND, H., JORANGER, E. and SEMB, A. (1976). Deposition of air pollutants in Norway. In Impact of acid precipitation on forest and freshwater ecosystems in Norway. Ed. H. Brœkke. SNSF-Project, NISK, 1432 Aas-NLH, Norway. pp 15-35.

GARLAND, J.A. (1974). Dry deposition of SO_2 and other gases. In Proc. of the Conf. on deposition and resuspension of atmospheric pollutants. Richland September 1974.

GORHAM, E. (1958). The influence and importance of daily weather conditions in the supply of chloride, sulphate and other ions to fresh waters from atmospheric precipitation. Phil. Trans. R. Soc. Series B 241, 147-78.

Van HAUT, H. and STRATMANN, H. (1970). Farbtafelatlas über Schwefeldioxid-Wirkungen an Pflanzen. W. Girardet: Essen.

HAWKSWORTH, D.L. and ROSE, F. (1976). Lichens as pollution monitors. Studies in Biology no. 66 Arnold; London.

HEGGESTAD, H.E. and HECK, W.W. (1971). Nature, extent and variation of plant response to air pollutants. Adv. Agron. 23, 111-45.

HICKEY, D.A. and McNEILLY, T. (1976). Competition between metal-tolerant and normal plant populations: a field experiment on normal soil. In litt.

JENNY. H. (1941). Factors of soil formation. McGraw-Hill: New York.

JOHANSSON, O. (1959). On sulphur problems in Swedish agriculture. (In Swedish). K. Lantbr Högskolans Annlr., 25, 59-169.

JONSSON, B. and SUNDBERG, R. (1972). Has the acidification by atmospheric pollution caused a growth reduction in Swedish forests? A comparison of growth between regions with different soil properties. Rapp. Uppstatser Inst. för skogsproduktion, Skogshogskolan. No. 20.

KELLER, T. (1976). Auswirkungen niedriger SO_2 Konzentrationen auf junge Fichten. Schweiz. Z. Forstwes., 127, 237-51.

KELLOG, W.W.., CADLE, R.D., ALLEN, E.R., LAZARUS, A.L. & MARTELL, E.A. (1972). The sulphur cycle. Science, N.Y., 1975, 587-96.

KETTLWELL, H.B.D. (1956). Further selection experiments on industrial melanism in the Lepidoptera. Heredity, Lond., 10. 287-301.

KNABE, W. (1970). Kiefernwald-verbreitung und Schwefeldioxid-Immissionen im Ruhr-gebiet. Staub-Reinhalf 30, 32-5.

LINZON, S.N. (1972). Effects of sulphur dioxide on vegetation. For. Chron., 48, 182-6.

LOFTFIELD, J.V.G. (1921). The behaviour of stomata. Publ. Carnegie Instn., 314, 1-104.

MALMER, N. (1976). Acid precipitation: chemical changes in the soil. Ambia, 5, 231-4.

NICHOLSON, I.A., KINNAIRD, J.W. and PATERSON, I.S. (1977). Personal communication.

ODEN, S. (1976). The acidity problem - an outline of concepts. Proceedings of the first international symposium on acid precipitation and the forest ecosystem, Ohio, 1975. pp.1-36. USDA Forest service general technical report NE-23.

RENZETTI, N.A., and DOYLE,.G.J. (1960). Photchemical aerosol formation in sulphur dioxide - hydrocarbon systems. Int. J. Air Pollut., 2, 327-45.

RUTTER, A.J. (1977). Personal communication.

SHARP, P.G. (1972). In The Countryman p. 31. The Countryman: Burford, Oxford.

SHRINER, D.S. (1976). Effects of simulated rain acidified with sulfuric acid on host-parasite interactions. Proceedings of the first international symposium on acid precipitation and the forst ecosystem. Ohio, 1975. pp. 919-25. USDA Forest service general technical report NE-23.

TAMM, C.O. and ARONSSON, A. (1972). Research Notes (Royal College of Forestry, Department of Forest Ecology, Stockholm) no. 12 pp. 1-53.

TAMM, C.O. and COWLING, E.B. (1976). Acidic precipitation and forest vegetation. Proceedings of the first international symposium on acid precipitation and the forest ecosystem. Ohio, 1975. pp. 845-55. USDA Forest service general technical report NE-23.

TINGEY, D.R., REINHERT, R.A., DUNNING, J.A. and HECK, W.W. (1971). Vegetation injury from the interaction of NO_2 and SO_2. Phytopathology 61, 1506-11.

WELLBURN, A.R., CAPRON, T.M., CHAN, H.S. and HORSMAN, D.C. (1976). Biochemical effects of atmospheric pollutants on plants. In Effects of air pollutants on plants. pp. 105-14. Ed. T.A. Mansfield. University Press: Cambridge.

WILLIAMS, R.J.H., LLOYD, M.M. and RICKS, G.R. (1971). Effects of atmospheric pollution on deciduous woodland I: Some effects on leaves of Quercus petraea (Mattuschka) Liebl. Environmental Pollution, 2, 57-68.

WU, LIN, BRADSHAW, A.D. AND THURMAN, D.A. (1975). The potential for evolution of heavy metal tolerance in plants. III The rapid evolution of copper tolerance in Agrostis stolonifera. Heredity, Lond., 34, 165-87.

NATIONAL SOCIETY FOR CLEAN AIR

44th CLEAN AIR CONFERENCE

SEPTEMBER 19 - 22, 1977

HARROGATE

RADIOACTIVITY AND THE NUCLEAR FUEL CYCLE

Dr. Roger H. Clarke
Berkeley Nuclear Laboratories, CEGB

This paper is published by permission
of the Central Electricity Generating Board

136 North Street
Brighton BN1 1RG
England

1. INTRODUCTION

Uranium is a completely different fuel from all the other present-day energy sources. The main energy sources, fossil fuels, are carbon compounds which react with oxygen when they burn, producing heat and carbon-dioxide. The chemical elements present before combustion are still present in the same quantities afterwards. Uranium, however, releases energy when the atom splits apart and forms other elements, this process being known as fission. The energy produced by fission derives from the conversion of a very small amount of the original mass into energy, because the combined mass of the products of fission is slightly less than that of the original uranium. The fission of uranium was first demonstrated in the laboratory in 1938 and in 1942 the first nuclear reactor was built, actually on a squash court at the University of Chicago.

In 1955 the U.K. Government announced the world's first civil nuclear power programme and by 1962 the Central Electricity Generating Board had commissioned its first two reactors at Berkeley in Gloucestershire. The twin reactors at Berkeley have now been successfully producing electricity for 15 years during which time eight other nuclear power stations of similar design and increasing electrical output have been commissioned. These are sited as shown in Fig.1 at Bradwell in Essex; Hunterston in Ayrshire, operated by the South of Scotland Electricity Board; Hinkley Point in Somerset; Trawsfynydd in Gwynedd; Dungeness in Kent; Sizewell in Suffolk; Oldbury in Avon; and Wylfa in Gwynedd. The CEGB is now in the process of commissioning four new advanced reactor stations at Hinkley, Dungeness, Hartlepool in Teeside and Heysham in Lancashire (Fig.1). In the year 1976/77, the existing 8 nuclear stations produced 12% of the electricity generated by the CEGB at a net cost of about 60% that of fossil fuels even allowing for the increased building costs of the nuclear plant and the resulting savings to consumers have been between £100 million and £200 million in that year.

These power stations are one stage in a complex sequence of processes collectively known as the Nuclear Fuel Cycle shown schematically in Fig.2 and which includes the mining of the uranium, its fabrication into fuel

elements, the treatment of the fuel after leaving the reactor to extract useful nuclear fuel (reprocessing), and the storage of wastes. At each stage in the cycle there may be releases of radioactivity to the environment and in this paper the sources of these releases will be explained and typical quantities quoted. In order to put these releases into perspective it is useful first to review the natural levels of radioactivity to which man is subjected. The principles of nuclear power production and the differences in design between the various reactor types in operation are then described so that their effects on environmental releases both at the reactor and the fuel reprocessing plant are more easily appreciated.

2. THE NATURAL RADIOACTIVE ENVIRONMENT

2.1 Radioactivity

Matter is made up of atoms and an atom is the smallest particle into which an element can be split chemically. It consists of a nucleus of neutrons and protons surrounded by a nebulous cloud of electrons. The number of protons, which are positively charged, determines the element that the atom represents; hydrogen has one proton and uranium has 92. Protons, and neutrons which are uncharged, are about 2000 times heavier than electrons so that the mass of an atom is concentrated in the nucleus. In addition, for a given number of protons, there can be varying numbers of neutrons which give rise to stable "isotopes" of the element; for example, lead (Pb) is found with four naturally occurring isotopes, $^{204}_{82}Pb$, $^{206}_{82}Pb$, $^{207}_{82}Pb$ and $^{208}_{82}Pb$. Each lead isotope has 82 protons, but the number of neutrons varies from 122 to 126 to give mass numbers (total neutrons plus protons) of 204 to 208, and their relative abundances are 1.4%, 24.1%, 22.1% and 52.4% respectively.

When the number of protons exceeds 83 (Bismuth) all atoms are unstable, that is the nucleus will change spontaneously into another nucleus in an attempt to become more stable. This change, which is known as 'radioactivity', is accompanied by the emission of one of three types of radiation, α, β or γ radiation, and whichever is emitted depends on the actual nucleus concerned in its attempts to achieve a more stable configuration. α-radiation is the emission of a particle consisting of two neutrons and two protons; β-radiation is the emission of an electron

from the nucleus when an uncharged neutron spontaneously changes into a positively charged proton, thus changing the element to which the isotope belongs, but not its mass number. γ-radiation is different from the other two in that it is not particulate, but is similar to X-radiation and results from movements of neutrons and protons within the nucleus without transformation of either. γ-radiation usually accompanies α- and β-decay as the resulting nucleus "settles" to its most compact form.

The rate at which an isotope decays is characterised by its "half-life" which is the time taken for half the number of the original nucleii present at any given time to transform themselves into the new nucleus. After two half-lives there will be one quarter of the original number of atoms remaining and one eighth after three half-lives. The unit of measure of the rate of emission of radiation is the "curie" (Ci) which corresponds to the decay rate of one gram of radium, a radioactive element first separated by Madame Curie from uranium ores.

2.2 Contributions to Terrestrial Radioactivity

Uranium is found in nature with two radioactive isotopes $^{235}_{92}U$ and $^{238}_{92}U$ with half-lives of 713 million years and 4150 million years respectively. This means that there is now about half the ^{238}U that there was when the earth was formed, but only about one sixty-fourth of the original amount of ^{235}U since it has decayed through about six half-lives. The uranium isotopes decay with the emission of up to 14 α- and β-particles to stable isotopes of lead as shown in Fig.3 and it is seen that different isotopes have different half-lives, from a fraction of a second to thousands of millions of years. It is noted that another isotope of uranium, $^{234}_{92}U$ exists as a daughter product from the decay of $^{238}_{92}U$.

The isotope $^{238}_{92}U$ together with the single isotope of the radioactive element thorium, $^{232}_{92}Th$, seem to be the parents of most of the natural radioactivity in the world. There are other naturally occurring radio-isotopes, notably an isotope of potassium, $^{40}_{19}K$, a β-emitter with a half-life of 1280 million years. Since the human body contains some 140 grams of potassium, there are several thousand disintegrations per second in each of our bodies from this natural element alone. Uranium and ^{40}K are present in the earth's crust to the extent of about 3 parts per million

while thorium is about four times as abundant. ^{40}K constitutes the overwhelming activity of sea-water, its mass in the world's oceans being some sixty-three thousand million ($6.3x10^{10}$) tonnes or 460 billion ($4.6x10^{11}$) Curies. The world's oceans are estimated to contain about 4000 million tonnes of uranium and as a consequence some thousand tonnes of radium - a billion (10^9) Curies. Finally, since one of the daughter elements of ^{238}U decay is a gas (radon) with about a 4-day half-life, the atmosphere contains about 1 Curie of radon gas per cubic kilometer in equilibrium with its daughters (Fig.3). Against this natural radioactive background, the fission process will be considered and the man-made contributions to the radioactive environment outlined.

3. NUCLEAR POWER

3.1 The Fission Process

The ^{235}U isotope which is present only as 0.7% of the element uranium, has the property that when it captures a neutron, it has a high probability that it will fission. The nucleus breaks up into two new nucleii, the "fission products" and releases on average 2.5 neutrons per fission. The energy released is carried as the kinetic energy of the "fission products" which are stopped within a microscopic distance in uranium fuel, giving up their energy to heat which is then usable to produce electricity.

The fission products formed have a statistical distribution of mass and charge (proton number) around the middle region of the periodic table of the elements (Zinc to the rare earths) and are radioactive isotopes which decay via β-emission thereby increasing their proton to neutron ratio until they become a stable isotope. Most of the isotopes have very short half-lives, but a small number have longer ones, for example that of Strontium-90 is 28 years and for Caesium-137 it is 30 years.

When a ^{238}U isotope captures a neutron it is most unlikely to undergo fission, but decays radioactively via two β-emissions to produce an isotope of a new element, plutonium, $^{239}_{94}Pu$. The importance of the reaction is that the isotope formed is readily fissionable like ^{235}U

so that the production of plutonium makes useful fuel from the 99.3% of uranium which as ^{238}U is of little benefit.

Since there are several high energy neutrons released in fission, if one of them can be made to cause another fission, the process will be self-sustaining. Such a situation is known as 'criticality' and it clearly depends on the concentration of fissile atoms. With natural uranium alone it is not possible to make a 'critical' mass no matter how large an amount, because the concentration of ^{235}U is too low. If however the neutrons can be slowed down, the probability of ^{235}U undergoing fission increases, especially at slow neutron velocities comparable with that of molecules in a gas at moderate temperatures. These are known as thermal neutrons and in order to "thermalise" neutrons light atoms of mass similar to the neutron mass are required which are known as 'moderators'.

A thermal reactor is thus an assembly of fuel elements containing fissile material separated by a moderator which slows the neutrons down, as shown in Fig.4. A coolant passes over the fuel elements and is used to raise steam in a heat exchanger exactly as in a conventional plant. Thermal reactors have provided the basis of nuclear power production to date and differences in design that have evolved, with a bewildering variety of acronyms, basically revolve around the competing benefits of a range of coolants and moderators.

3.2 Thermal Nuclear Reactors

A thermal power reactor family tree is shown in Fig.5 where it is seen that there are two classes of reactor, gas-cooled and water-cooled. The gas-cooled ones use graphite as a moderating material, while the water-cooled reactors use either light or heavy water. Heavy water is naturally occurring as about one part in 6000 in light water (H_2O) and consists of deuterium oxide (D_2O), deuterium being an isotope of hydrogen which has one neutron in addition to the single proton.

3.2.1 Gas-cooled Reactors

The present CEGB operating reactors utilize natural uranium metal encased in a can of magnesium alloy, known as Magnox and a fixed graphite moderator. The fuel elements are about one metre in length and 2.5 cm

in diameter (Fig.6), eight such elements making up one channel of fuel and about 4000 channels forming one reactor. The coolant, carbon dioxide (CO_2), passes over the elements, which are finned to provide additional heat transfer, at a pressure of up to 40 atmospheres contained in a steel pressure vessel. A schematic representation of a Magnox reactor is given in Fig.7. A significant advance was made with the Oldbury reactors where prestressed concrete pressure vessels allowed increased coolant pressure and greater structural integrity.

The limiting feature to development of Magnox reactors was the gas coolant peak temperature, because of the properties of the uranium metal. To raise the gas outlet temperature and thus improve station efficiency, the Advanced Gas-cooled Reactors (AGRs) were developed, eight of which the CEGB is commissioning. To run fuel at the higher temperatures required, the ceramic uranium dioxide (UO_2) was needed together with stainless steel cans. The fuel element design is shown in Fig.8 and consists of 36 pins about 1.5 cm diameter and about 1 metre in length. Again there is a fixed graphite moderator and 6 or 8 fuel assemblies fit into one channel through which CO_2 passes under pressure and about 400 channels make up one reactor. Because of the increased neutron absorption in steel and oxygen compared with Magnox the uranium must be slightly enriched to about 2% ^{235}U. Although the fuel costs are higher, the improvement in station efficiency and the additional power which can be produced before the fuel elements are replaced, make AGRs significantly cheaper than Magnox.

The last type of gas-cooled reactor which is under development and not used commercially yet is the High Temperature Reactor (HTR). This uses uranium dioxide or uranium carbide (a better heat conductor) as fuel in the form of small microspheres embedded in a graphite matrix. There are fewer wasteful neutron captures in structural and cladding materials and the use of ceramics enables gas outlet temperatures to be high enough for process heat, in steelmaking for example. The coolant is helium which is a better heat transfer medium than CO_2, but requires a very leak-tight circuit. It is considered to be a very safe design from the physics of the core and could effectively convert the non-fissile thorium,

^{232}Th, to the fissile isotope $^{233}_{92}U$ which would make an additional contribution to energy sources.

Gas-cooled reactors are considered inherently more safe than liquid cooled ones, because any sudden loss in liquid coolant pressure would cause the liquid to vapourise thereby reducing markedly the cooling capacity.

3.2.2 Water-cooled Reactors

While Britain and France were developing Magnox reactors, the USA was developing water-cooled reactors principally for propulsion of submarines. The greatest advantage of light water is that neutrons are thermalised within a centimetre of water whereas the distance in graphite is about 20 cms. Thus the fuel pins are close together and the size of the core is much smaller than a Magnox or AGR reactor. The penalty is that light water captures neutrons and the fuel must be enriched in ^{235}U. The cladding material is an alloy of zirconium, zircaloy, which captures few neutrons. Such reactors are known as Light Water Reactors (LWR) and the water acts as both coolant and moderator. There are two sub-groups of LWRs, the first and most widely adopted around the world is the Pressurised Water Reactor (PWR) shown schematically in Fig.9. In the PWR the light water is held under a pressure of about 150 atmospheres by a thick steel pressure vessel so that it removes heat without boiling. The water flows from the core through a heat exchanger where low pressure water boils to raise steam.

The second type of LWR is a Boiling Water Reactor (BWR) which has water under significantly less pressure than the PWR so that the water boils as it approaches the top of the core. The steam is separated directly and sent to the turbines; there is no heat exchanger. The disadvantage of the system is partly the difficulty in obtaining good efficient steam conditions.

Finally for water cooled reactors, the Canadians have developed a heavy water moderated and cooled reactor, CANDU (Canadium Deuterium Uranium) fuelled with natural uranium because the neutron captures in D_2O are very small and again Zircaloy provides fuel cladding. Rather than relying on a pressure vessel, as does the PWR, CANDU operates with a

pressure tube design in which each fuel element is contained and the moderator is at atmospheric pressure surrounded by a callandria. Heavy water passing over the fuel elements under high pressure removes heat and passes through a heat exchanger to raise steam. In the British version, the Steam Generating Heavy Water Reactor (SGHWR), shown schematically in Fig.10, there is a similar pressure tube design, but the coolant is light water which is allowed to boil in the core and the steam is separated and fed directly to the turbines as in a BWR. The SGHWR utilises enriched uranium fuel and stainless steel cladding. It is currently the U.K. Government's preferred choice of reactor system.

3.3 Fast Reactors

3.3.1 The Principle of Breeding

It was mentioned above that ^{238}U, while not fissile, is converted into fissile ^{239}Pu by neutron capture. This happens in thermal reactors and by the end of irradiation of a fuel element, most of the power will be produced from fissions in ^{239}Pu, but some plutonium nucleii remain in the fuel. In fact the ^{239}Pu also captures neutrons without fissioning to form heavier isotopes some of which are fissile and others are not. This 'breeding' of plutonium to some extent counteracts the burnup of ^{235}U nucleii; even so, since there is only 0.7% of fissile nucleii in uranium, the best that might be expected with plutonium production is to utilise 1 to 2% of the total uranium for fission. The amount that can be used is limited by the fact that in a thermal reactor, the number of fissile nucleii created is less than those destroyed; that is the ratio of these quantities which is known as the "breeding ratio" or "conversion ratio" is less than one.

If a means could be found of increasing this breeding ratio above unity then there would be the possibility of utilising 100% of the uranium mined by converting all the ^{238}U to the fissile isotopes of plutonium. This would increase the energy worth of existing uranium by a factor of about 60.

Thermal reactors have neutron losses in metallic components of the core because of moderation and breeding ratios are very much less than one; there are also some losses of fuel in reprocessing and fabrication so that

a breeding ratio significantly in excess of unity is required. This can be obtained with an unmoderated reactor where the chain reaction is sustained by "fast" neutrons having energies close to their birth energies in fission, particularly if the fuel is plutonium. This is because plutonium produces more neutrons per fission than ^{235}U and fissions that occur with "fast" rather than thermal neutrons produce a higher neutron yield. Because fission is less probable with fast neutrons than with slow neutrons, the fuel must be highly enriched in a fast reactor and in order to be economic higher neutron flux densities and a very compact core are required.

3.3.2 The Liquid Metal Cooled Fast Breeder Reactors (LMFBR)

The major development of this type of fast reactor has been in Europe and presently France and the U.K. have operating prototypes, the U.K. one being known as PFR (Prototype Fast Reactor) built at Dounreay (Fig.1) and producing 250 MW of electricity. A schematic representation of the reactor is given in Fig.11. The fuel in the core is admixed uranium and plutonium, typically 20% plutonium and the coolant is liquid sodium metal chosen in order to remove heat at a sufficient rate and to minimise neutron thermalisation. Very large numbers of neutrons leak from the small core which is surrounded by a blanket of uranium in which additional plutonium will be bred. This blanket is removed at intervals and the plutonium removed in reprocessing for use in either thermal or fast reactors. Because of the vigorous reaction between sodium and water, there is a secondary sodium circuit which removes the heat from the primary circuit and is used to raise steam thus preventing water reaching the primary sodium.

4. ACTIVITY RELEASED IN THE NUCLEAR FUEL CYCLE

The nuclear fuel cycle shown in Fig.2 begins with the mining and milling of the uranium which is not done in the U.K. Supplies of uranium ore are imported from South Africa and Canada by British Nuclear Fuels Ltd. (BNFL) to Springfields near Preston (Fig.1) where fuel fabrication takes place; enrichment is carried out at their Capenhurst plant in Cheshire (Fig.1). After irradiation in the CEGB's reactors, irradiated fuel is transported back to Windscale on the Cumbrian coast (Fig.1) where all reprocessing takes place. Each stage in the cycle has its own character-

istic radioactive releases which are now considered in detail.

4.1 Mining and Milling

After the uranium ore is mined it is crushed and chemical solvents used to leach out the uranium oxide which is radioactive, but because of the long half-lives only slightly so. Because of the radioactive decay of uranium the extraction process leaves radioactive wastes known as "tailings" which consist of the natural decay series shown in Fig.3 starting with ^{230}Th and ^{231}Pr, which have half-lives of 77,000 years and 32,500 years respectively. The most radiotoxic daughters in the decay series are ^{226}Radium (half-life 1,600 years) and the gas ^{222}Radon (half-life 3.8 days) which, because they are in equilibrium with ^{238}U exist in quantities of about 0.5 Curie per tonne of uranium. Since towards ten thousand tonnes of uranium are mined in the world each year, there are several thousand Curies of radium and radon gas plus all their daughter products which are in tailings piles produced each year.

4.2 Enrichment and Fuel Fabrication

At Springfields the imported uranium ore is converted to uranium metal for use in Magnox reactors, or into the gas uranium hexafluoride which is sent to Capenhurst for the enrichment process. The process at Capenhurst is gaseous diffusion through a porous membrane which the lighter ^{235}U atoms do more readily than do those of ^{238}U but since the difference is small, many stages are needed until the required enriched uranium hexafluoride is obtained. This enriched gas is returned to Springfields for processing into enriched oxide fuel. The environmental releases of radioactivity are simply those of uranium and its natural decay series; the airborne discharges from Capenhurst are about 5 kg of uranium per year and virtually zero aqueous discharges, while from Springfields in 1975 there were essentially no airborne releases and liquid discharges were about 50 Ci of α-activity and 2000 Ci β-activity.

4.3 Reactor Releases

4.3.1 Gas-cooled Reactors

The Magnox reactors in operation utilise on-load refuelling as

will the AGRs; the fuel channels can be replaced during reactor operation whereas with water reactors it is usual to shut down the reactor once a year to change the core. The Magnox reactors have instrumentation to sense any release of fission products from a fuel channel which can be quickly replaced if necessary. There is thus very little atmospheric release of radioactivity due to leakage from the radioactive core. Typical discharges would be fractions of a Curie in a year as shown in Table 1 and will be due to activation products in graphite, etc. The major atmospheric release from early Magnox reactors is the 1.8 hour half-life β-active isotope ^{41}Argon which is an activation product of the argon content of air which is drawn around the outside of the steel pressure vessels inside the biological shield for cooling purposes, and is subjected to a small neutron flux. Although the ^{41}Ar discharges are large, the activity decays away quickly.

TABLE 1

Discharges of Radionuclides from CEGB Reactors in 1974 (Curies)

Station	Radioactivity in liquid discharges (excluding tritium)	Tritium in liquid discharges	Atmospheric Aerosols	Atmospheric ^{41}Ar
Berkeley	23	57	0.004	16,000
Bradwell	90	117	0.004	15,000
Hinkley Pt.	125	39	0.04	72,000
Trawsfynydd	19	60	0.02	152,000
Dungeness	69	20	0.09	33,000
Sizewell	16	253	0.008	62,000
Oldbury	33	37	0.14	Not Applicable
Wylfa	0.5	134	0.004	Not Applicable

Liquid discharges are partly due to tritium, ^{3}H, a β-emitting activation product of water vapour which is left in the core when the reactor has had atmospheric air inside it during shutdowns; the gas cir-

cuit is continually purged of water and typical annual discharges can be up to a few hundred curies. The other source of liquid radioactive discharges is water from the cooling ponds in which fuel elements are stored after removal from the core where they radioactively decay and cool before being transported to Windscale. Pondwater is treated before discharge but some residual activity is present in the effluents. One fission product, Caesium, is susceptible to leaching from fuel by water and this is the major source of liquid active discharges although a wide variety of nuclides can be measured in very small quantities, mainly corrosion products. Wylfa has no cooling pond, the irradiated fuel elements being cooled by CO_2 and thus liquid discharges from this station are essentially only the tritium from the core water vapour.

4.3.2 Water-cooled Reactors

In water reactors the sources of wastes, in the absence of failed fuel, are corrosion products and radioactive gases. The corrosion products will depend on the constructional materials (cobalt, iron, chromium) and the radioactive gases will be isotopes of nitrogen formed by neutron reactions with oxygen. In practice, since the core is not accessible in operation, a certain number of fuel element cladding failures are experienced so that some fission gases and vapours can find their way into the coolant. For reactors with direct steam cycles, BWRs and SGHWR there is a direct pathway for the radioactive gases to be discharged to atmosphere. This is at the condenser stage beyond the steam turbine which will be constantly under vacuum and any radioactive gases are removed with other gases. Early BWR's discharged large amounts of fission products gases (Krypton and Xenon) to the atmosphere, several hundred thousand Curies per year together with a few curies of particulates and vapours. PWRs having a secondary steam circuit have had far smaller discharges of radioactive gases to atmosphere, but recently constructed BWRs and PWRs, as well as the SGHWR design, include delay tanks where the fission gases can decay for periods of up to a few days so that environmental discharges will be almost zero.

In water reactors the radioactivity in coolant water and plant effluents is removed by ion exchangers and ultimately appears on solid waste which is buried. Typical discharges of corrosion and fission products

in liquid effluents are shown in Table 2, where tritium releases are also given.

TABLE 2

Activities in Liquid Discharges from Water Reactors in 1972 (Curies)

Reactor	Year of Criticality	Mixed Fission and Corrosion Products	Tritium
BWR			
Dresden 1	1959	7	43
Nine Mile Point	1969	35	28
PWR			
Indian Point 1	1962	25	580
Ginna	1969	0.4	120

4.4 Reprocessing

Fuel is reprocessed partly to extract uranium and plutonium which can be used again as fuel, and partly because it facilitates the management of radioactive wastes which can be concentrated to relatively small volumes for convenient storage. With uranium metal from Magnox reactors, fuel is reprocessed within about a year of discharge from the reactor because of corrosion of the magnox cans in water which would allow fission products to leak. The irradiated fuel from advanced reactors using oxide fuel with stainless steel or zircaloy cladding, can be stored for very long periods before reprocessing, and indeed there is as yet no commercial oxide fuel reprocessing plant in the free world.

Magnox fuel arriving at Windscale is stored in ponds for at least four months for radioactive decay of short-lived isotopes; the magnox cans are then stripped from the fuel remotely in heavily shielded facilities and the uranium metal dissolved in nitric acid. At this stage some radioactive gases and vapours can be released from the fuel, which pass through filtering systems to the environment. The isotopes contributing shown in Table 3 are long-lived gases or elemental species principally of Krypton, and Tritium with some Iodine, Carbon, Strontium and Caesium.

The uranium and plutonium are extracted from the acidic solution

TABLE 3

Annual Radioactive Discharges to Atmosphere from Windscale Reprocessing Plant (Curies)

Year	^{3}H	^{14}C	^{85}Kr	^{90}Sr	^{129}I	^{131}I	^{137}Cs	Total other β	Total α
1973	8×10^{3}		1.2×10^{6}	0.72		1.2	-	19	0.18
1974	1.2×10^{4}		1.2×10^{6}	0.15		0.01	-	2.8	0.18
1975	8×10^{3}	3×10^{2} (a)	8×10^{5}	0.40	4×10^{-2} (a)	0.008	0.88	1.76	0.08

(a) estimates made by NRPB.

leaving about 99.9% of the fission products in the waste. This highly active waste is concentrated by evaporation and transferred to high integrity storage tanks on site to await eventual glassification. At Windscale the wastes are stored in double skinned stainless steel tanks, the radioactive decay heating being removed by water passing through pipes in the tanks. There are eight tanks of 70 m^3 and four of 150 m^3 capacity which contain all the wastes of the nuclear power programme, both military and civil. One tonne of Magnox fuel, which generates 30 million kW hours of electricity produces 40 litres of waste and to date there are some 600 m^3 of active waste being stored. Liquid effluents arise at various stages in the separation and concentration of both the wastes and the uranium/plutonium and the typical liquid effluent discharges are shown in Table 4. The discharges are monitored and specific

TABLE 4

Activity Discharged to Sea from BNFL Windscale (Curies)

Source	1972	1973	1974
β-activity	1.4×10^{5}	1.3×10^{5}	2.1×10^{5}
^{106}Ru	3.1×10^{4}	3.8×10^{4}	2.9×10^{4}
^{144}Ce	1.4×10^{4}	1.5×10^{4}	6.5×10^{3}
^{90}Sr	1.5×10^{4}	7.5×10^{3}	1.1×10^{4}
α-activity	3.9×10^{3}	4.9×10^{3}	4.6×10^{3}
Plutonium	1.6×10^{3}	1.8×10^{3}	1.4×10^{3}

isotopes identified; the majority of the β-activity is due to discharges of caesium, particularly ^{137}Cs, the other isotopes being preferentially released by various chemical processes. On average one third of the α-activity is plutonium, the remainder being due to other α-emitting isotopes present in the fuel. The liquid wastes are discharged into the Irish sea through a pipeline which extends 2.5 km beyond the coast. The movement of the wastes are extensively monitored and the environmental consequences well known, as will be demonstrated by subsequent papers.

5. CONCLUSIONS

This paper has described the main natural radioactive environment and against this background the principles of nuclear power and the differences between various reactor types have been explained. Sources of radioactivity released to the environment have been identified and typical quantities given. Reactors have been shown to have very small radioactive releases to the environment while the reprocessing plant is the largest contributor at present.

6. BIBLIOGRAPHY

1. Royal Commission on Environmental Pollution, Sixth Report, Nuclear Power and the Environment, Cmnd 6618, HMSO, 1976.

2. Sir John Hill, The Nuclear Fuel Industry, in Fuel and the Environment, Eastbourne, 1973.

3. Prof. W.V. Mayneord, Radiation and Health, Rock Carling Fellowship, The Nuffield Provincial Hospitals Trust, 1964.

4. National Radiological Protection Board, The Data Submitted by the U.K. to the U.N. Scientific Committee on the Effects of Atomic Radiation for the 1977 Report to the General Assembly, NRPB-R47, 1977.

5. Fox, R.W., Presiding Commissioner, Ranger Uranium Environment Enquiry, First Report, Australian Government Publicity Service, Canberra, 1976.;

6. Prof. J. Rotblat, (Ed.) Nuclear Reactors: To Breed or not to Breed, Taylor and Francis, London, 1977.

7, H. Howells, (Ed.) Radioactive Waste Disposals and Associated Monitoring Data, BNFL annual reports, HP/ER/71-73, 74, 75.

FIG. 1. Location of Nuclear Fuel Plants and Power Stations in the UK.

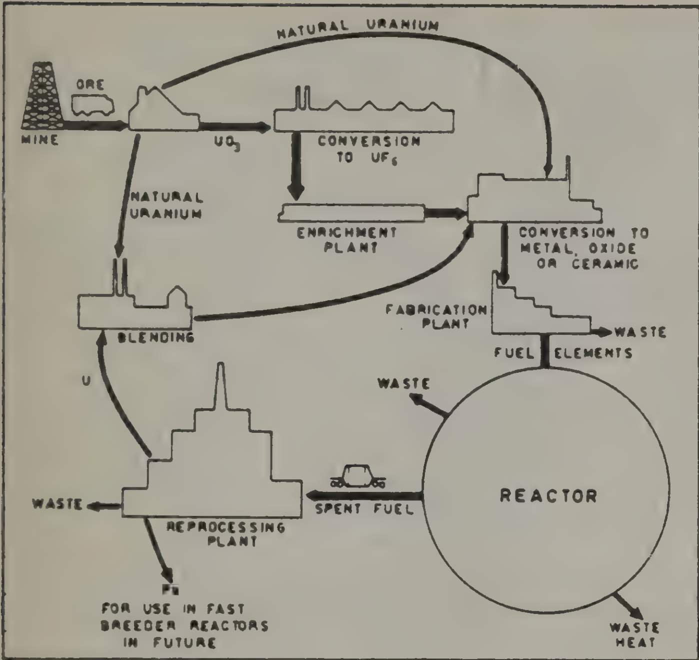


Figure 2. The Nuclear Fuel Cycle.

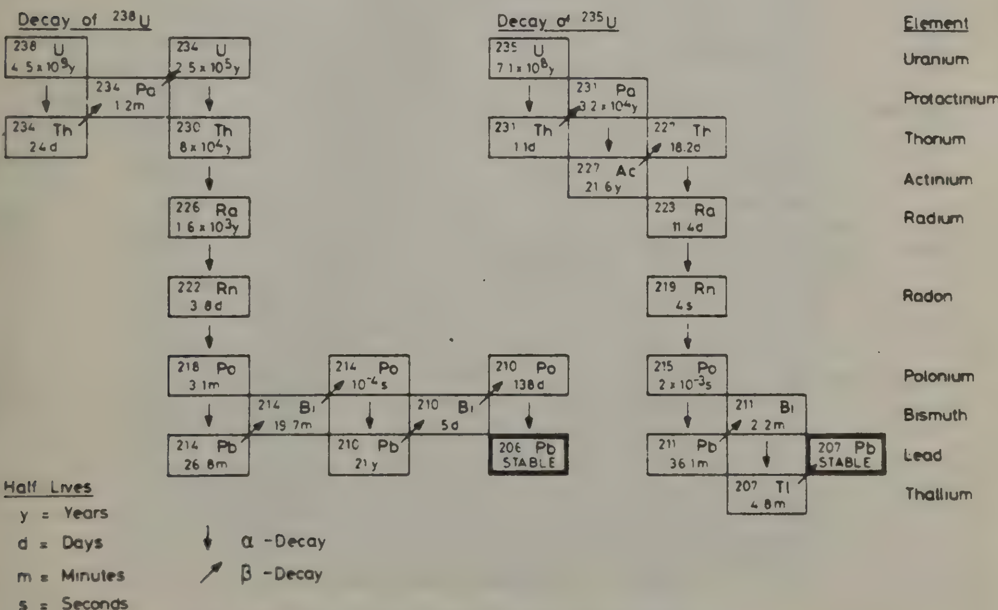


FIG. 3 The Natural Radioactive Decay Series

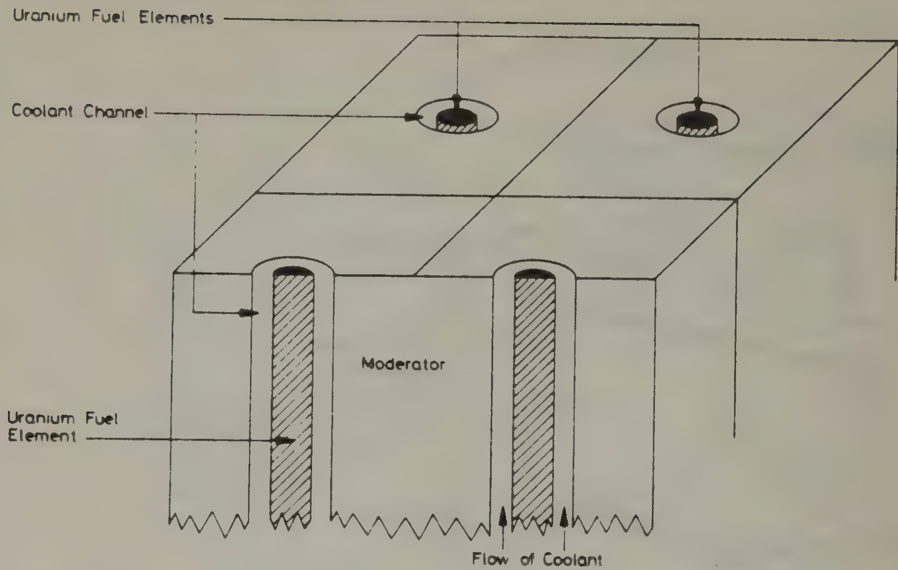


FIG 4 Arrangement of Fuel and Moderator in a Gas Cooled Reactor

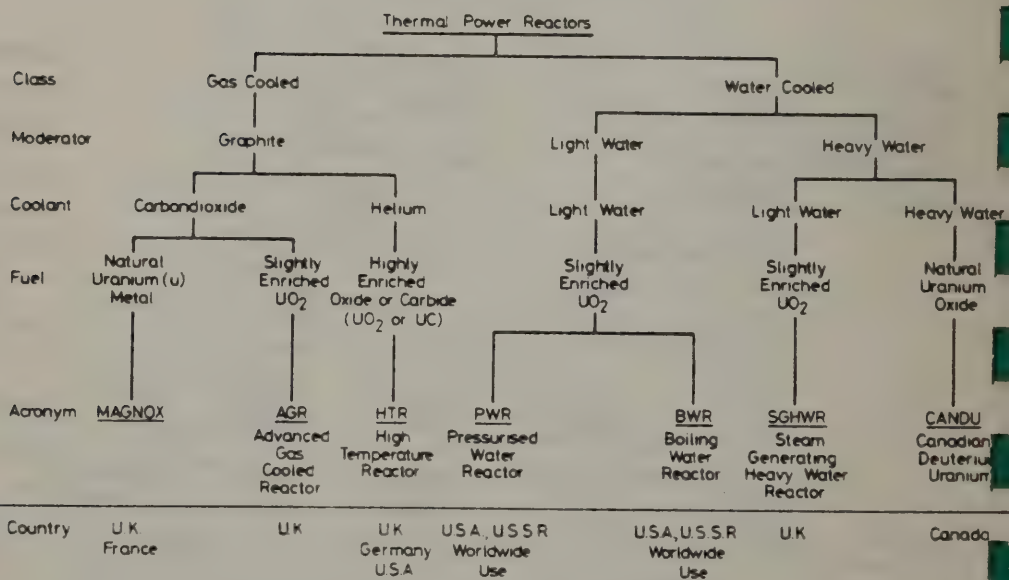


FIG. 5 Thermal Reactor Family Tree

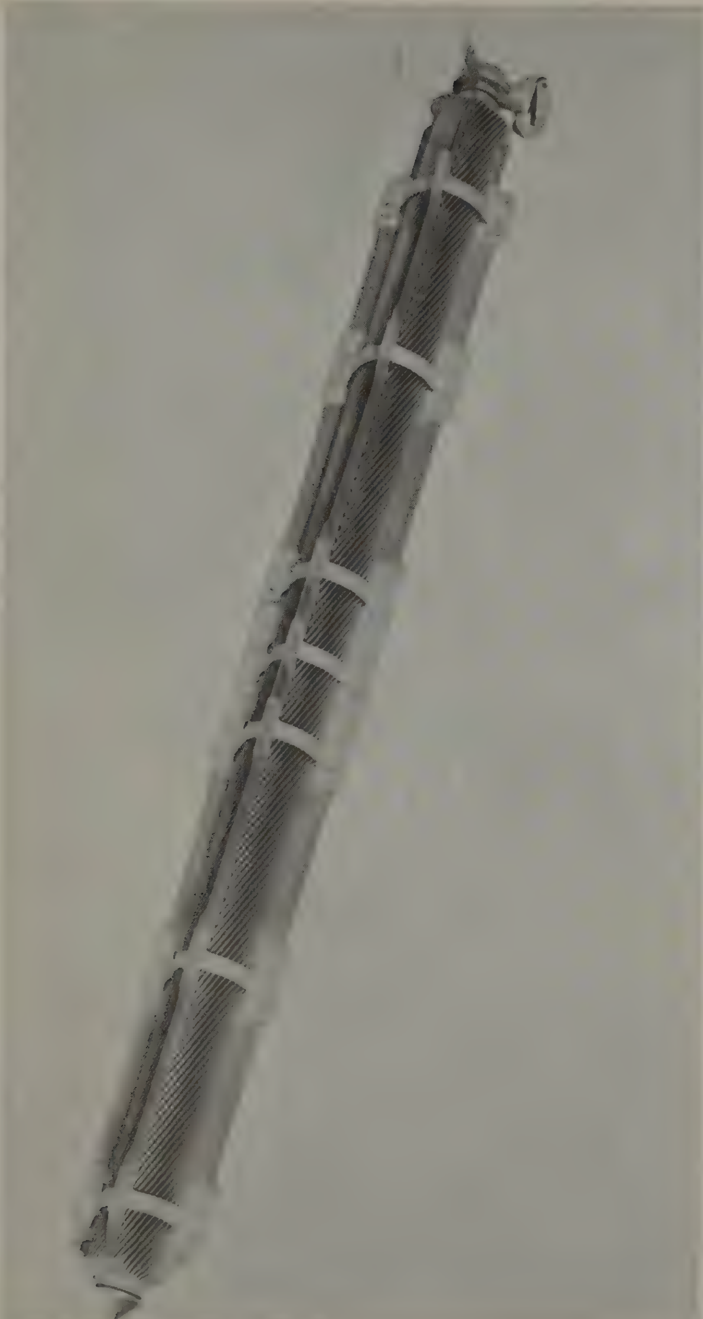


Figure 6. Typical Magnox Fuel Element showing can finning.

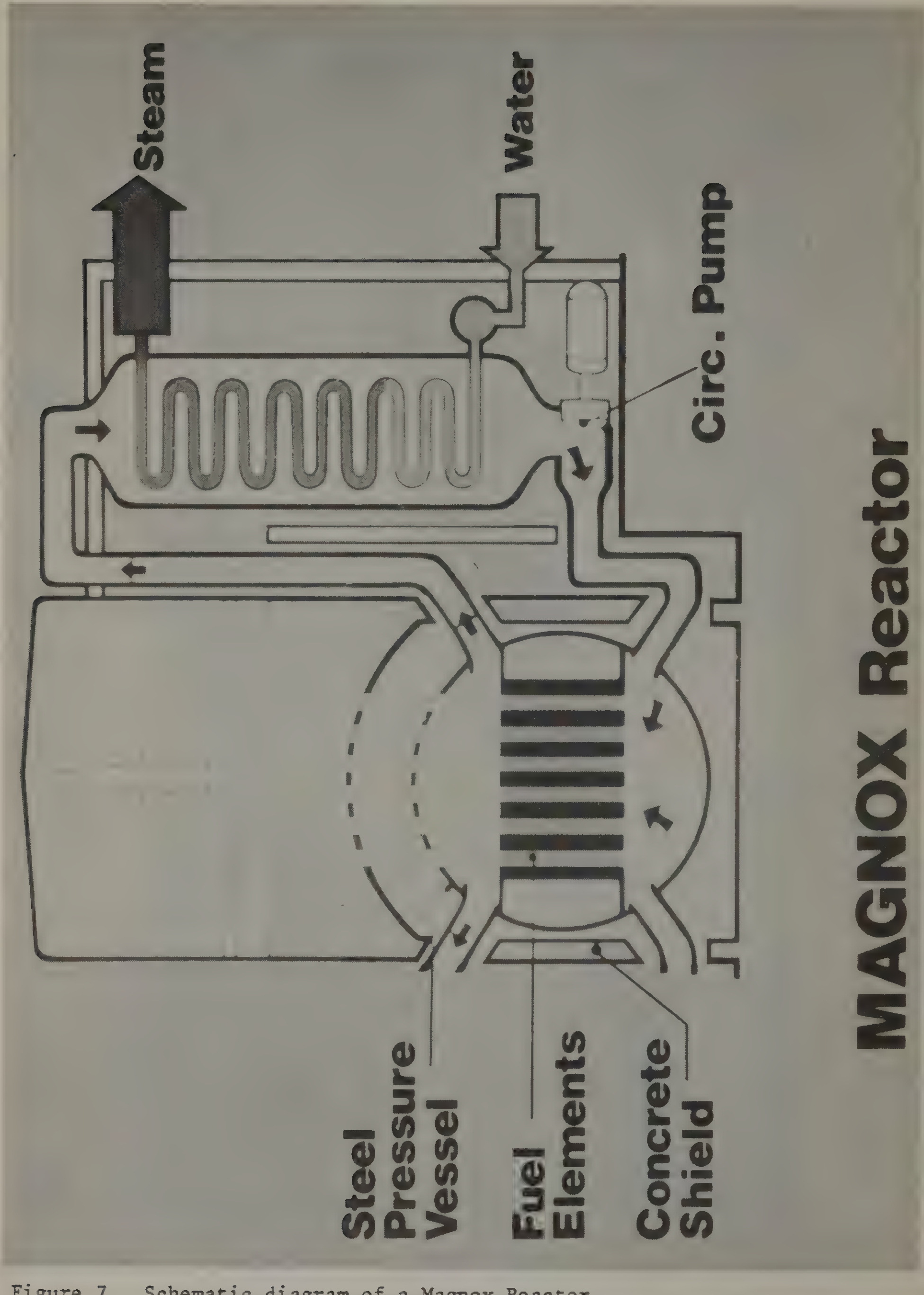


Figure 7. Schematic diagram of a Magnox Reactor.

Figure 8. A cutaway model of an AGR fuel element showing fuel pins.

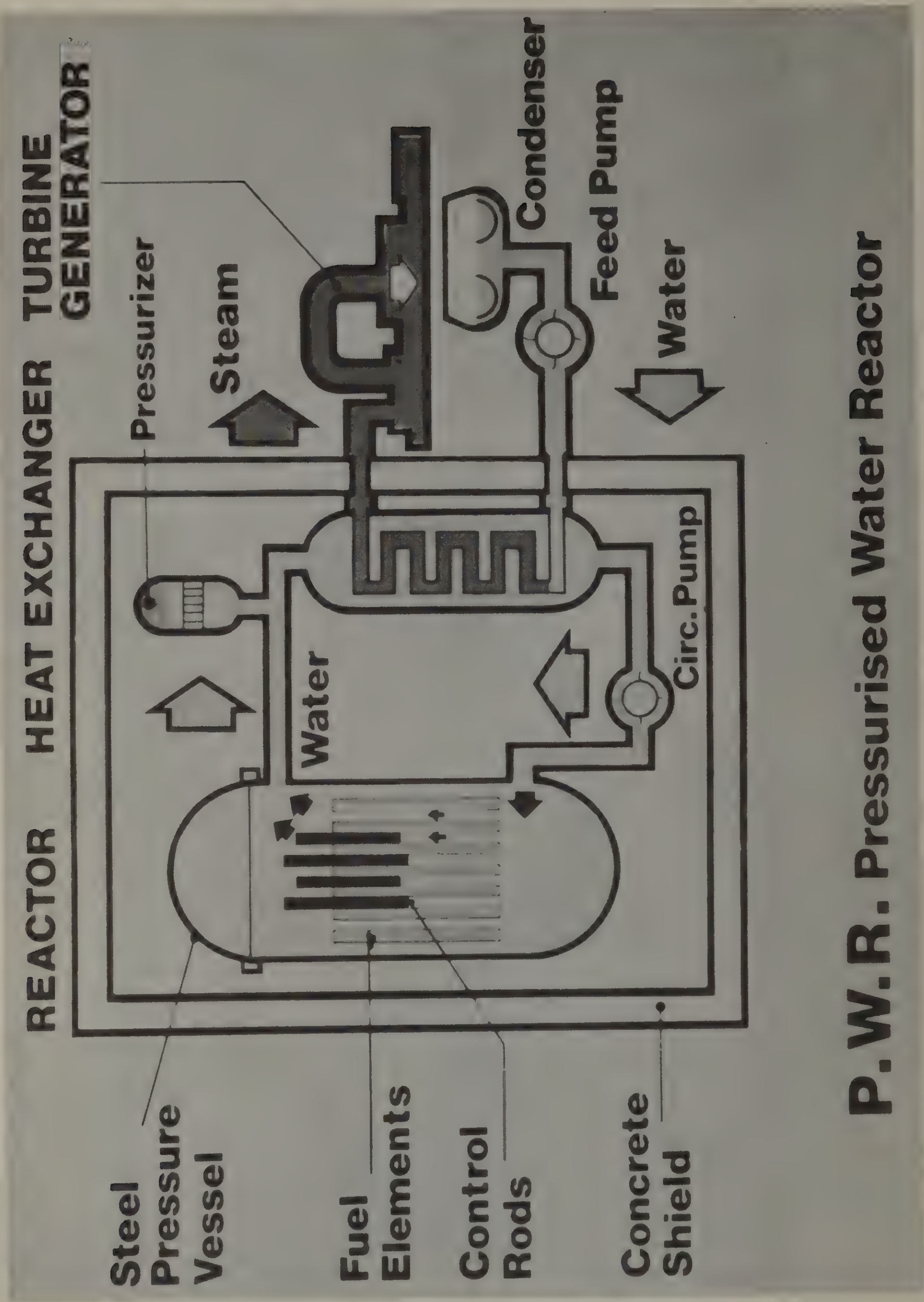


Figure 9. Schematic diagram of a light water reactor.

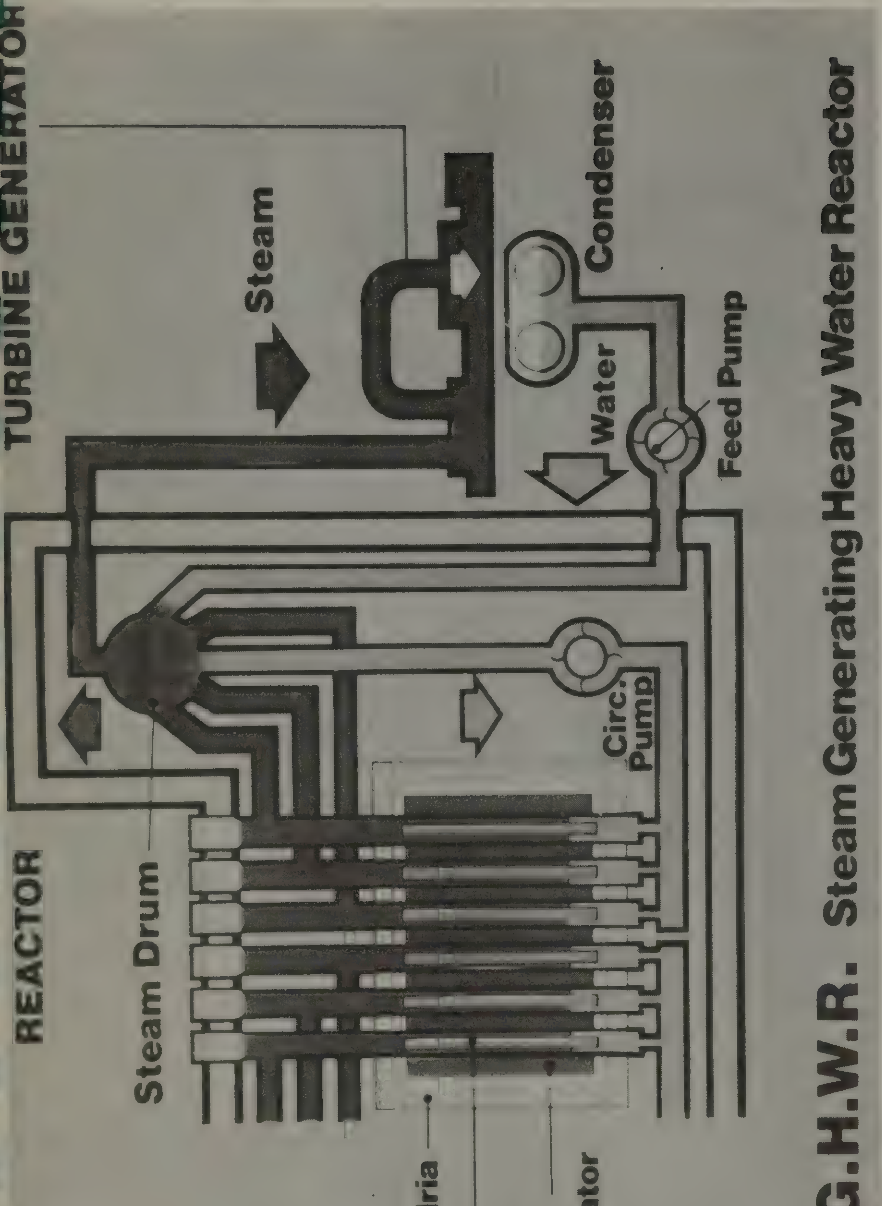


Figure 10. Schematic diagram of heavy water reactor.

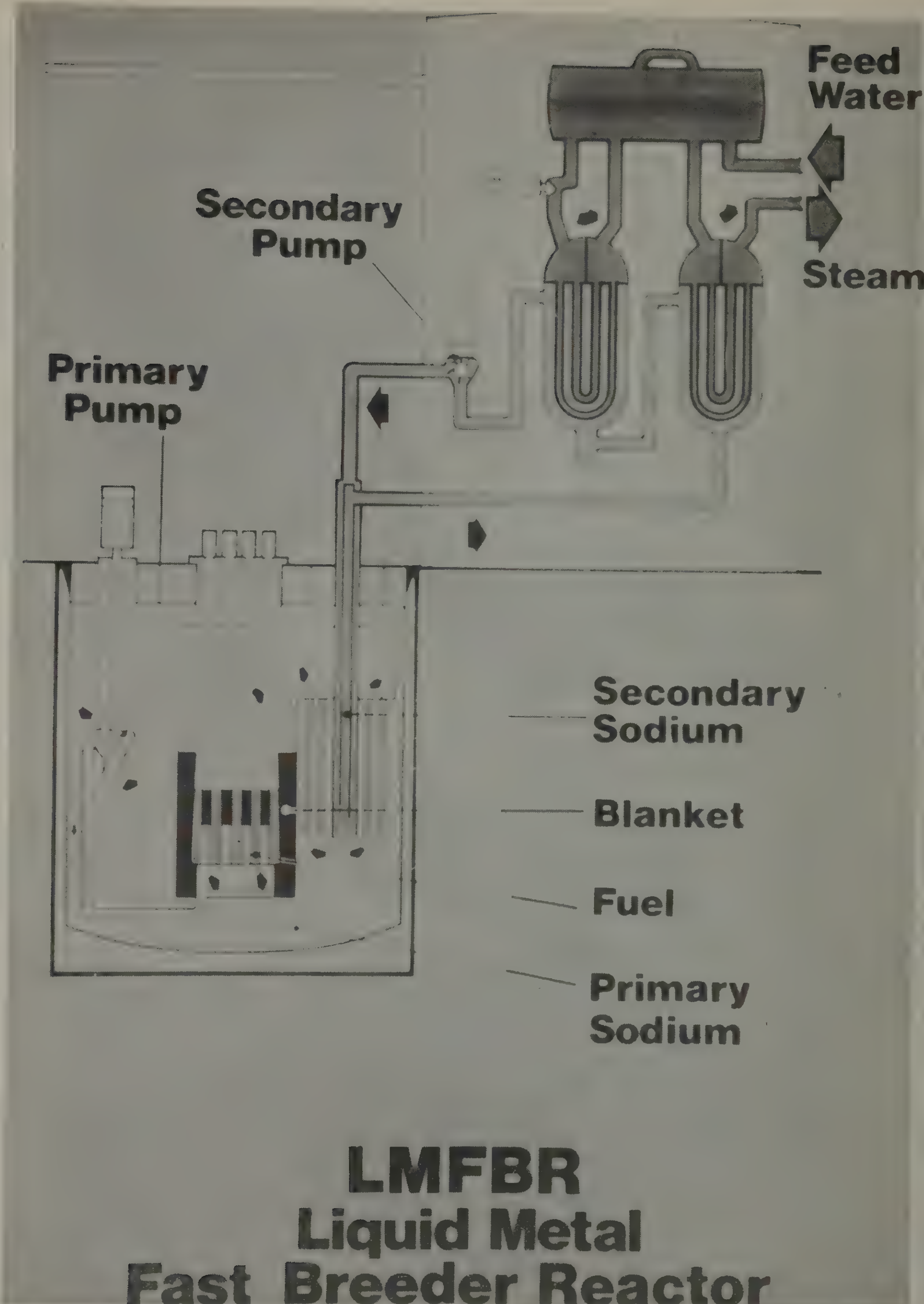


Figure 11. Schematic diagram of a Fast Reactor.

NATIONAL SOCIETY FOR CLEAN AIR

44th CLEAN AIR CONFERENCE

SEPTEMBER 19 - 22, 1977

HARROGATE

THE CONTROL OF AIRBORNE RADIOACTIVE EMISSIONS FROM NUCLEAR POWER STATIONS IN THE U.K.

J. Beighton
H.M. Deputy Chief Alkali and Clean Air Inspector

136 North Street
Brighton BN1 1RG
England

1. INTRODUCTION

This paper considers the subject from the viewpoint of radioactive waste discharges coming under authorisation procedures necessary to protect public health and the environment. It does not cover such questions as reactor safety or site licensing or conditions affecting workers engaged in radioactive industry.

2. RADIATION STANDARDS AND POLICY OBJECTIVES

Basic standards in this field are formulated by the International Commission on Radiological Protection (ICRP). This is composed of eminent scientists chosen at four-yearly intervals and it is independent of Governments. ICRP is recognised by all major countries and its recommendations are used as a basis for standards. For example ICRP standards have been endorsed by the Medical Research Council for use in United Kingdom. ICRP standards have recently been reviewed.

The principles of waste disposal policy in UK are based on a Government White Paper published in 1959(1) and are embodied in the Radioactive Substances Act 1960. There are three fundamental criteria:-

2.1. To ensure, irrespective of cost, that no member of the public shall receive more than the relevant ICRP dose limits (e.g. 0.5 rem per year for the whole body).

2.2. To ensure, irrespective of cost, that the whole population of the country shall not receive an average dose of more than 1 rem per person in 30 years (i.e. one fifth of the ICRP limit relating to the genetic risk).

2.3. To do what is reasonably practicable, having regard to cost, convenience and the national importance of this subject, to reduce doses far below these levels.

The third point above is similar to the ICRP recommendation that all doses should be kept as low as is readily achievable. It should be mentioned here that the White Paper referred to above is being reviewed and will take account of the recent ICRP review.

Departments dealing with the authorisation of discharges have to translate the above standards into terms of practical control and will grant authorisation only after they have determined the requirement of the operator to discharge waste and the capacity of the environment to receive the waste. In principle the latter aspect requires sufficient knowledge of what happens to radioisotopes in the environment so that one can determine the most critical pathway by which they get back to man and also the critical group of the population who would receive the largest dose. From such data Derived Working Limits (DWLs) can be worked out. A DWL for environmental contamination is the concentration in the relevant material (e.g. in milk) which would lead to exposure of the public, or the critical

group thereof, at a rate equal to the ICRP recommended dose limit. A DWL for a radioactive effluent would be the discharge limit, the release rate of which, from calculation, would lead to such concentration in the relevant environmental material. A DWL may be based on an actual or a hypothetical situation in order to check that no potential sterilization of an area is involved. The word "critical" as used above is meant to indicate "the most significant" path or group in terms of estimating dose potential. The above principles and policy apply to all forms of radioactive waste, i.e. solid, liquid and gaseous, discharged to land, water or air. Also they cover all disposers of waste in UK including those concerned with nuclear fuel manufacture and reprocessing and research and development as well as nuclear power stations. In terms of time available, and the field with which he is familiar, the author has chosen to concentrate on airborne emissions and nuclear power stations.

3. PROCEDURE IN APPLYING POLICY OBJECTIVES

All proposals for discharge of radioactive waste have to satisfy a system of prior authorisation administered by government departments under the Radioactive Substances Act 1960. Table 1 shows the departments concerned and the control inspectorates involved. Although different departments cover different parts of UK there is a general uniformity of approach.

These departments are responsible for setting any limits to discharges but there is consultative procedure required by the Act through which the views of local interests are sought before an authorisation is issued. Similar steps are taken before an authorisation is changed. Authorisations are legally enforceable.

In UK the variations of situation both environmentally and technically are such that it has not been considered practicable or best to set discharge limits for general application. Instead the practice is to assess situations on merit, case by case, but always within the principles laid down earlier. In addition to consideration of scientific data the administration has to be aware of other factors such as economic, social and technical.

An organisation seeking to discharge "gaseous" waste from a nuclear power station has to apply to the appropriate government departments for authorisation. The term "gaseous" includes any airborne discharge i.e. gases, mists, dusts, etc. Application would also be made if seeking to add to or alter an existing authorisation. If the matter involves a new power station project then the applicant will also have contacted the department(s) and inspectorates concerned at a much earlier stage and established a continuing liaison to provide detailed information on plant design proposals with particular reference to emission control, and related data. The Inspectorates make a careful assessment and may require alterations and/or improvements. If in due course the plans are acceptable, and all requirements are satisfied in construction, authorisation is granted although not until after due consultation by the government department(s) with local authorities and others in the area

TABLE 1

Ministerial and departmental responsibilities within the UK for radioactive waste disposal from major nuclear sites

Country	Minister	Executive Government Department	Control Inspectorate involved
England	Secretary of State for the Environment	Dept of Environment	Radiochemical Inspectorate HM Alkali & Clean Air Inspectorate (ACAI)
	Minister for Agriculture Fisheries and Food	Ministry of Agriculture Fisheries and Food	MAFF Food Science Div-Atomic Energy and Fisheries Radiobiological Laboratory and ACAI
Wales	Secretary of State for Wales	Welsh Office	Radiochemical Inspectorate HM Alkali & Clean Air Inspectorate (ACAI)
	Minister for Agriculture Fisheries and Food	Ministry of Agriculture Fisheries and Food	MAFF Food Science Div-Atomic Energy and Fisheries Radiobiological Laboratory and ACAI
Scotland	Secretary of State for Scotland	Scottish Development Department	HM Industrial Pollution Inspectorate for Scotland
N Ireland	Secretary of State for N Ireland	Dept of Environment for N Ireland	Alkali and Radiochemical Inspectorate for N Ireland

Notes

1. There are not yet any major nuclear sites in N Ireland but departmental provision has been made.
2. ACAI are an inspectorate within Health and Safety Executive but have duties under Radioactive Substances Act 1960 on an agency basis for DOE, MAFF and Welsh Office.
3. Nuclear Installations Inspectorate (NII) and HM Factory Inspectorate of the Health and Safety Executive are not listed above since NII are concerned with public protection but more from site safety and licensing aspects and HMFI from industrial occupational aspects.

concerned.

4. CONTROL REQUIREMENTS AND PHILOSOPHY

In terms of practice so far authorisations for gaseous emissions from nuclear power stations have not normally included specific limits for the nuclides discharged. The authorisations have contained conditions requiring the operators to use best practicable means to:-

(i) Minimise the radioactivity of the waste discharged.

(ii) Ensure that the radioactivity of such waste does not exceed any limit which may for the time being be specified by the responsible Ministers.

The term "practicable" has regard (amongst other things) to local conditions and circumstances, financial implications and to current state of technical knowledge. The author has described this as "in terms of practice so far" because it may not necessarily continue in quite this form. It must be mentioned that one recommendation of the Sixth Report of the Royal Commission on Environmental Pollution is that each nucear site should have clear standards for airborne emissions to which to work and the Government has agreed this in principle[7]. It is necessary however in practice to ensure that any figurative limits are not seen as something up to which an operator may work regardless, since best practicable means, taking account of experience and techniques, may well show that discharges can be reduced much below these figures. There should not be any impression that the existing "best practicable means" philosophy means a loose approach to design and performance required. In detailed consideration of technical proposals the inspectorates involved are fully concerned to ensure that each of the policy objectives mentioned in section 2 above are well satisfied. In certain cases there may be particular 'letters of understanding' which contain specific points relating to emission levels which may not be exceeded without due consultation and further agreement, or action which has to be taken in various situations. In practice it is policy criterion 2.3. (above) requiring exposure to be minimised which really qualifies the levels which are acceptable.

It is a considerable help to designers of nuclear power stations and ancillary equipment, and to inspectorates, if a new proposal is similar to, and can be compared with, existing plant and operating experience. For example the later Magnox type stations benefitted from the earlier ones. On a new project where experience is not available to suggest tighter standards the design approach in UK has been to fix the upper dose limit from gaseous discharges to 5% of the ICRP dose limit and then to work backwards to emission control standards, for significant radionuclides, using pessimistic factors at each calculative stage. This means that in practice the environmental effect will very probably be much less than originally allowed. On the first of the AGR type of nuclear power stations the authorisation carried with it a written understanding that a discharge limit of 5% DWL applied for two radionuclides of chief concern.

TABLE 2

Commercial Nuclear Power Stations in UK

Country	Availability	Location	Type	Approx Size MW Electrical Output
England and Wales	Already built and operating	Berkeley Bradwell Hinkley 'A' Trawsfyndd Dungeness 'A' Sizewell Oldbury Wylfa	All these sites have twin reactors Magnox type, gas cooled. All reactors have steel pressure vessels except those built on Oldbury and Wylfa which have concrete pressure vessels	332 * 292 * 540 * 460 * 425 * 500 * 440 * 1000 *
		Hinkley 'B'	Advanced gas cooled (AGR) reactors. Concrete pressure vessels	1320 +
	In process of construction	Dungeness 'B' Heysham Hartlepool	Advanced gas cooled (AGR) reactors. Concrete pressure vessels	1200 + 1320 + 1320 +
Scotland	Already built and operating	Hunterston 'A'	Magnox type. Gas cooled twin reactors. Steel pressure vessels	329 *
	Already built and operating	Hunterston 'B'	AGR - twin reactors Concrete pressure vessels	1320 +

(* Present rating)
(+ Design rating)

The concept of best practicable means in the authorisation also includes an obligation on the operator to provide and use sampling and monitoring equipment to check gaseous emissions and possible effects on the environment and to submit regular returns of results to the authorising department(s). There is also an understanding that further control measures will be required if found necessary from experience.

5. NUCLEAR POWER STATIONS IN UK

Table 2 shows the position regarding commercial nuclear power stations in UK. Table 3 gives a few details on the various types of thermal reactor relevant to British practice[2]

TABLE 3

Types of Thermal Reactor relevant to British Practice

Type	Magnox	AGR	SGHWR
Fuel used	Natural uranium	Uranium oxide - 2% enriched	Uranium oxide 2 - 3% enriched
Fuel Element cladding	Magnox	Stainless steel	Zirconium
Moderator	Graphite	Graphite	Heavy Water
Coolant	Carbon dioxide	Carbon dioxide	H_2O

Magnox reactors were developed in UK in the 1950s. They represent the first British phase of commercial power reactors. The fuel elements are of natural uranium metal cast and machined to cylindrical shape about 1 metre long and 25 mm diameter. They are encased in "magnox" which is a magnesium alloy. These elements are fitted into a large carbon moderator block. The coolant is carbon dioxide under pressure. The earlier design of Magnox type have steel reactor pressure vessels with concrete shields between which pass cooling air. The heat exchangers, which extract heat from the carbon dioxide to generate steam for power production, are external to the reactor pressure vessels. The later designs at Oldbury and Wylfa have pre-stressed concrete cylindrical pressure vessels and internal heat exchangers. In this way the separate concrete shield and cooling air factors of the earlier designs are dispensed with.

The Magnox type has been followed by the Advanced Gas-cooled Reactor (AGR). The latter represents an aim to improve thermal efficiency by raising steam temperatures. The fuel is uranium oxide, the elements are clad with stainless steel and the reactor core temperature is higher. The coolant is still carbon dioxide and containment is still in pre-stressed concrete pressure vessels. The SGHWR reactor is one in which there is much British interest as a possibility for the future. At present there is only one unit prototype of 100 MW capacity built by AERE at Winfrith.

6. THE NATURE OF RADIOACTIVE AIRBORNE EMISSIONS FROM MAGNOX AND AGR STATIONS

The radiations which may result from airborne discharges or be otherwise manifest in the atmosphere can be divided into alpha particles (helium nuclei), beta particles (electrons) and gamma radiation (penetrating electromagnetic radiation). These may cause damage to human tissue due to ingestion, inhalation or maybe from outside the body. The particular critical materials and routes of major importance will depend on circumstances involved. It is important to distinguish between the relatively small amounts of emission in normal operation, which may vary at times due to operational procedures or abnormalities, maintenance drills, etc., and the emissions which could occur in the event of accidental release. Very careful and detailed provisions are made in reactor design to guard against any major failures which could give accidental release. Items of prime concern in such escapes would be Iodine-131 and Caesium-137. This paper is concerned with normal airborne emissions coming under day to day control. The radioactivity is distributed amongst gases, mists or aerosols and dusts. The principle radioactive gas is Argon-41. On the earlier stations of Magnox type, this results mainly from neutron irradiation of the small amounts of argon in the cooling air passing up through the space between the pressure vessel and the concrete shield. The later designs of concrete pressure vessel have eliminated this although even with stations of the latter type some Argon-41 will arise from activation in the reactor system of traces of Argon present in the carbon dioxide coolant. Discharges of the latter take place periodically due to refuelling operations or through blowdowns of the circuit. Figures for Argon-41 discharge at the earlier type CEGB Magnox stations are within the range 0.5 to 4.8 mCi per second.[(3)]

Carbon 14 is also produced by gas-cooled reactors and discharged in the form of carbon dioxide.

Aerosols and dusts in airborne discharges are derived from four sources:-

(i) Carbon dioxide coolant

(ii) Ventilation of active ancillary operations on site

(iii) Naturally occurring radioactive nuclides absorbed on dust particles together with fall-out which are drawn into shield cooling space with

the cooling air.

(iv) Dust particles in the shield cooling air which become radioactive by flux irradiation from the reactor as they pass through the cooling space.

Variations occur in the quantities of and actual isotopes present according to the original source of coolant gas, the specification of graphite in the reactor core, the different features of operation in steel pressure vessel reactors as compared with concrete pressure vessel types and also because of differences between Magnox and AGR designs. For example in steel pressure vessel Magnox installations Cobalt 60 and Chromium 51 from steel occur in the emissions. Tritium is formed from lithium which is an impurity in the graphite material of the reactor core. Sulphur-35 arises from irradiation of impurities in the reactor system and amounts occurring are greater than originally expected. This latter applies particularly to the Magnox installations of concrete pressure vessel design and to the AGR design.

Apart from deliberate controlled discharges such as mentioned above for the coolant, or incidental irradiation as in the shield cooling air, part of the radioactive emissions to air arise from small percentage leakage factors in the overall system.

7. CONTROL AND MONITORING - DESIGN AND PRACTICE

Essential aims are to minimise emissions by design and operation, to measure them and to carry out tests on the surrounding area to check their effect, if any, on the environment.

7.1. FILTERS

Several types of filter plant are used at the Magnox and AGR stations and these are dealt with below:-

(i) Coolant (CO_2) filters The coolant is continuously filtered in a bypass loop during its use in the reactor pressure system so as to remove radioactive particulates as they occur. Any actual coolant discharges are passed through other filters (blowdown filters) before discharge at suitable height.

These bypass and blowdown filters are typified in Table 4.[5]

(ii) Shield cooling air At Magnox stations which have shield cooling air (steel pressure vessels) it is filtered by glass fibre roll filters to remove particulates before being discharged at high level.

(iii) HEPA Filters These are high efficiency particulate air filters, or absolute filters. They are installed after pre-filters in ventilation extract systems serving sections of the site where

airborne contamination occurs. They are of unit construction and arranged in banks according to size of installation and to facilitate changing and checking. Absolute filters have wider application than just ventilation air and design can be varied to accommodate requirements of temperature, fire resistance, chemical attack, etc.

TABLE 4

Bypass and Blowdown Filter
Media at CEGB Magnox Stations

Station	Bypass Filters	Blowdown Filters
Bradwell	Cyclones	Ceramic candles
Hinkley Point 'A'	Ceramic candles	Ceramic candles
Sizewell	Sintered iron	Sintered bronze

Manufacture is to high specification but care is needed to avoid damage to the filter or its seals before or during installation. There is also the possibility of leakage due to faulty fitting of the filter unit. Tests are therefore necessary. It may be decided to carry out specification tests now and again on external rigs but in practice the important thing is to do filter tests in situ for the reasons indicated above. These should be done on first installation and at about 2 year intervals thereafter, unless changes are made or particular maintenance needed meantime, whereupon retesting should be done.

To check manufacturers' data, on external rig, if required, use can be made of British Standard 3928 applying sodium flame penetration test. For in situ testing the CEGB appear to favour the method based on condensation nuclei and using the Nolan Pollak Condensation Nucleus Counter.

(iv) Iodine Adsorption Plants These are provided for emergency use on Magnox and AGR stations and in addition the latter have them at certain points for normal operation.

Emergency use - provision is made for a major incident such as a fire in a fuel channel whereby fission products could be released to the gas coolant circuit. To minimise loss to atmosphere the reactor coolant can be released under pressure through this adsorption plant which consists of coarse and fine particulate filters, a special charcoal bed and then further particulate filters. The charcoal bed removes radioactive

iodine which is considered to be the major problem in such circumstances.

Normal use - In the AGR design special precaution has to be taken for day-to-day operation to cater for the possibility of iodine 131 leaking into the coolant circuit from a failed fuel pin, pending attention of course to rectify the latter. Thus iodine adsorption plants are provided for normal reactor coolant blowdown and also at the auxiliaries section handling charge/discharge machine depressurisations etc. The charcoal is of granular form. It is spray impregnated with potassium iodide. The iodine removal mechanism is principally that of physical adsorption on a very large surface area but the potassium iodide aids performance by providing some chemisorption capacity. Each batch of charcoal made for CEGB is tested in the laboratory before use. In situ tests of charcoal beds are also carried out periodically to ensure that they remain satisfactory for use if and when required.

7.2. MEASUREMENT OF AIRBORNE RADIOACTIVITY

In addition to minimisation of emissions an authorisation requires sufficient measurements to be done at discharge points and in the environment.

7.2.1. EMISSION TESTS - MEASUREMENT OF PARTICULATES AT DISCHARGE

This is done at all major points. A portion of the gas flow is bypassed through a filter paper to collect the particulate and the radioactivity contained therein is measured by counting equipment after allowing a 72 hour decay period so as to eliminate certain items naturally present as background activity in air. From relative flow rates in sampling and main discharge the total particulate emission can be deduced. It should be pointed out however that such emissions amount to only a few mCi/year per station.

Gases Consideration has to be given to the possibility of direct radiation from the gases emitted, i.e. gamma type radiation. The amount of such activity, which is mainly from Argon 41, is measured during early operation of the stations and checked periodically.

Special emission tests Individual techniques have had to be evolved for measuring particular emissions and time does not allow detail here. One example however is Sulphur 35 which is of special interest in operation of AGR installations.

7.2.2. ENVIRONMENTAL MONITORING

It is necessary to be satisfied that a nuclear power station does not cause unacceptable increases in the amounts of radiation and radioactivity found in the locality. District surveys are carried out prior to fuel loading at a nuclear station and then continued after-

wards. Concerning airborne items the following are of interest -

Milk monitoring Radioactive material can be deposited on pasture land and through grass eaten by cattle radioactivity can find its way into milk. This is an important critical route when considering certain radionuclides. Representative samples of milk are collected from selected farms and analysed regularly for caesium 137, strontium 90 and iodine 131 which are potentially the significant and most hazardous nuclides via this route. Such items have rarely been detected at levels in milk above the background levels due to fall-out. These are very much less than the DWL values in milk current in the UK. Checks are also made in milk where sulphur 35 emissions may be concerned but so far measurements and estimates have been very reassuring in showing values representing extremely small fractions of the DWL.

Gamma dose rate measurements These are carried out at quarterly intervals at chosen fixed sites up to a distance of 5 miles around the power station. Results are carefully checked for any changes or trends. Measurements of integrated gamma dose are also taken at the station site perimeter over quarterly periods using film radiation monitors.

Tacky Shade Collectors These are devices to check particulate discharge. A collector consists of a wire "lamp shade" frame covered with a tacky gauze type of material. Particulate material sticks to it and can be tested for radioactivity. The shades are usually placed in pairs about 5 ft from ground level and sites around the station at about $\frac{3}{4}$ miles distant. They are compared with control samples taken at greater distances. These devices are very sensitive and can detect radioactivity at extremely low levels. Generally they have given results no higher than would be expected from normal background.

8. NUCLEAR POWER STATION INCINERATORS

Although not concerned primarily with production of energy for power it is perhaps useful to mention incinerators as a necessary ancillary on power station sites. They are used to burn site waste containing some activity and give rise to airborne emissions which need consideration in the initial design stage and control in subsequent operation. Two types of installation are employed. For low activity waste the incinerator is relatively simple in design with afterburner but not usually fitted with filters. Chimney height is modest. The aim is to obtain smokeless combustion and to burn material of such low contamination and inert type that special construction is not required and the amount of radioactivity emitted is considered minimal. A limit is placed on the radioactivity content of material which may be fed to this type. For medium and higher activity waste, also containing significant quantities of plastic, such as PVC, design and control have to be much more exotic. The combustion chamber is specially designed to obtain controlled feeding of material. An after-

burner is provided to complete combustion and a chemical scrubber to remove hydrochloric acid gases. A heat exchanger arrangement in the system cools the gases before the wet scrubbing and they are then reheated after scrubbing before they enter absolute filters to remove radioactive particles. The final chimney varies in height according to circumstances - it could be around 60 to 80 ft or as high as 120 ft in certain cases. The latter type of installation, particularly, has to be made in special materials to withstand heat and corrosion. Both types are equipped with instrumental control and tests are carried out to check the level of radioactivity in final discharge. These plants have not been without their problems - e.g. fire and excessive corrosion - and power station site incineration facilities are still not fully solved.

9. INFORMATION

Liaison Committees exist for each Nuclear Power Station area which bring together for meetings once per year representatives of the generating board, controlling government departments, local authorities and other interested bodies. At these meetings are available Environmental Monitoring Reports prepared and presented by the authorising departments which itemise various data including that on liquid and gaseous waste discharges and which serve to identify any changes and trends. Opportunity is thus provided for discussion and clarification of any items and the Committee is also available as a consultative point.

10. SUMMING UP

Vast amounts of time, effort and money are expended on the control of airborne, and also solid and liquid, discharges, from nuclear power stations. This mirrors the concern of governmental and power generation authorities to guard against potential hazards. Within the author's experience the principles of control of airborne discharges by best practicable means have enabled co-operative working liaisons to be established and the environmental record so far of CEGB stations, in this respect, has been reassuring. Data on airborne emissions give a picture well within safe limits when related to DWL values etc.

REFERENCES

1. ANON. The Disposal of Radioactive Waste Cmnd 884 (1959) HMSO.

2. Royal Commission on Environmental Pollution - Sixth Report - Nuclear Power and the Environmental Cmnd 6618 (1976) HMSO.

3. Individual and Collective Doses due to Argon 41 based on measured discharge notes from CEGB Reactors - R.H. Clarke & R. Wilson (CEGB).

4. Experience in complying with authorisation conditions for the discharge of liquid and gaseous radioactive effluents from CEGB Nuclear Power Stations - R.B. Pepper (CEGB).

5. Radioactive Waste from Nuclear Power Stations and its Discharge to the Environment - J.K. Jones, I. Dougall and M. Stead (CEGB).

6. Nuclear Power and the Environment - The Government's Response to the Sixth Report of the Royal Commission on Environmental Pollution - Cmnd 6820 (1977) HMSO.

NATIONAL SOCIETY FOR CLEAN AIR

44th CLEAN AIR CONFERENCE

SEPTEMBER 19 - 22, 1977

HARROGATE

EXPOSURE OF THE PUBLIC TO RADIOACTIVE DISCHARGES FROM THE NUCLEAR FUEL CYCLE

Pamela M. Bryant,
Senior Environmental Adviser
National Radiological Protection Board

and

Frances E. Taylor
Senior Scientific Officer in Environmental Studies Group
National Radiological Protection Board

136 North Street
Brighton BN1 1RG
England

INTRODUCTION

The effect on the environment, on the public and on society itself, of present and proposed operations of the nuclear fuel cycle is now the subject of substantial public debate. The year 1977 is noteworthy for the Public Inquiry into the proposed Oxide Reprocessing Plant at Windscale. It is expected that all the relevant safety, environmental and planning considerations will be fully examined. It was in 1967 that Dr. E.F. Schumacher gave the Des Voeux Memorial Lecture on "Clean air and future energy"(1) at the Conference of the National Society for Clean Air at Blackpool. In this lecture he raised nuclear issues evoking public interest today. Solutions for some of these, for example, methods of disposal of high activity fission product waste, are currently under investigation in the United Kingdom and elsewhere. The scope of this paper is limited, however, to a review of exposure of the public to radioactive discharges to the environment from routine operation of the nuclear fuel cycle.

This paper draws on a review presented at the "International Symposium on the Management of Wastes from the LWR Fuel Cycle" held at Denver in 1976(2). The methodology used for assessing the radiation exposure of the public arising from the discharge of radioactive effluents is summarised and attention is drawn to its limitations. The levels of radiation exposure resulting from the operation of thermal reactor fuel cycle installations in the United Kingdom in recent years are reviewed and the relevant primary radiological protection standards quoted. The paper concludes with a brief summary of a recent assessment of the radiological significance from long-lived radionuclides discharged from nuclear installations. For information on sources of effluents giving rise to exposure of the public, reference should be made to the paper entitled "Radioactivity and the nuclear fuel cycle" to be presented at this Conference by Dr. R.H. Clarke(3); for information on "The control of airborne radioactive emissions from nuclear power stations in the United Kingdom" reference should be made to the paper by Mr. J. Beighton(4).

No global and detailed review of radiation doses actually received by the public from nuclear fuel cycle installations is available in the literature. The United Nations Scientific Committee on the Effect of Atomic Radiation (UNSCEAR) attempted such a review, and its findings are given in its 1972 report(5). The Committee stated that the doses incurred by the population can be assessed either by an adequate knowledge of the quantities discharged and of the transfer parameters involved or by means of a programme of environmental monitoring that is usually related to pathways selected as being of the greatest importance. The Committee commented that both approaches had serious shortcomings for the dose assessment it required. Calculations based on transfer models were said to be subject to considerable uncertainty because of the complexity of the field conditions and because in many cases the simplified models available were unrealistic. Monitoring routines, on the other hand, were said to be frequently geared to ensure compliance with accepted limits and therefore provided insufficient information on the very low doses that might be incurred by members of the public. Data on discharges were said to be unavailable for some operating reactors and limited in scope for others, being mainly in the form of gross activity measurements and

therefore unsuitable for the estimation of doses. As a consequence, the Committee's 1972 report included few data on doses; the same Committee is once again compiling available information and will report in 1977. Perhaps the most cogent of the UNSCEAR comments is that many environmental monitoring programmes, certainly in the past, have not been designed for dose estimation purposes; it will be interesting to see whether there has been a substantial improvement in this direction over the last few years.

REFERENCES

1. E.F. Schumacher, Clean Air and Future Energy, Des Voeux Memorial Lecture presented at the Annual Conference of the National Society for Clean Air, 1967.

2. F. Morley and Pamela M. Bryant, Radiation Exposures to Man from Releases of Radioactive Effluents, page 489, Proceedings of the International Symposium on the Management of Wastes from the LWR Fuel Cycle, Denver, Colorado, CONF-76-0701, 1976.

3. R.H. Clarke, Radioactivity and the nuclear fuel cycle, This Conference.

4. J. Beighton, The control of airborne radioactive emissions from nuclear power stations in the UK, This Conference.

5. United Nations Scientific Committee on the Effects of Atomic Radiation, Ionising Radiation Levels and Efflects, United Nations, New York, 1972.

Printed and published by
National Society for Clean Air, 136 North Street, Brighton BN1 1RG, England

NATIONAL SOCIETY FOR CLEAN AIR

44TH ANNUAL CONFERENCE
19-22 SEPTEMBER 1977
HARROGATE

WHY CLEAN AIR?

PART 2
DISCUSSIONS

136 NORTH STREET
BRIGHTON BN1 1RG ENGLAND

CONTENTS

* These papers were not included in Part I of the Proceedings but will be found at the end of Part II.

SESSION 2

THE EFFECTS OF AIR POLLUTION ON HEALTH
Professor P.J. Lawther

THE EFFECTS OF AIR POLLUTION ON AMENITY
Professor K. Mellanby

Mr. E.F. Raven (East Midlands Division) opening the discussion, said that his assignment that morning has posed a real problem since there was virtually nothing with which he would have wished - or indeed dared - to take issue. He was accordingly taking up a theme, subject to odd digressions, which had been explicit in Professors Lawther's paper and implied in Professor Mellanby's - and that was the possible conflict of opinion on the direction of future efforts in defining and controlling the effects of air pollution whether upon people or upon amenity.

The sessions' two speakers were eminently qualified, both by scholarship and experience, to speak on matters of air pollution and the environment, and the fact that workers of that calibre were expressing distinct notes of caution about the future use of resources ought, he thought, as Shakespeare had said, to give us a pause.

He asked what could be done. All kinds of investigation for research, for evaluation, or as an aid to control could be continued; the levels of substances already subject to limits could be controlled still further, or new ones could be sought. More attention could be given to odour control; and domestic smoke control could be completed.

In some place measurement already went on apace. The WHO manual on Urban Air Quality Management recorded that the United States Environmental Protection Agency (EPA) had existing or proposed networks known as the Continuous Air Monitoring Programme (CAMP) , the Community Health and Environmental Surveillance System (CHESS), the Continuous Health Air Monitoring Programme (CHAMP) and the Regional Air Pollution Study (RAPS). Mr. Raven thought that the temptation to invent other possibilities was almost irresistable!

His attention had recently been drawn by an East Midlands member to one particular system of monitoring in use in the Netherlands, described amongst other places in an Open University Unit Study. This was germaine to the question of air quality guides criteria and standards to which Professor Lawther had referred. The preamble had stated that "processes discharging pollutants to the atmosphere should be switched off when the weather is such that large concentrations are expected at ground level". He thought that comment from certain areas of industry on that prospect would be of interest. The system had set out amongst other things to avoid cause for complaint from odours specifically from oil refineries, a problem to which Professor Mellanby had referred earlier. Based on sulphur dioxide measurements - which gas he commented, ought surely to hold the distinction of being amongst the most measured substances in existence - the system had used those as indicators of the nuisance value of other emissions. It had been pointed out in the study that it was by no means obvious that the emission of odorous compounds would be exactly parallaled by the emission of sulphur dioxide.

He said it would be useful to have comment on that but the fact remained that from 1973 to 1974 the incidence of what we called Phase 2 alerts which postponed all unnecessary blowing through pipelines and chimneys; which delayed filling, emptying and cleaning of tanks and imposed a stricter check on temperature and pressure controls had dropped by 50% in number and by more than 40% in duration.

He posed the general question of whether that system provided a better method of controlling pollution than could be achieved by best practicable means. If stricter limits were required would they be met simply by extending the shut down periods? The study had concluded by saying that for the present all advances in Environmental improvement had measures to reduce emission at source.

He thought that all present would agree on the desirability of environmental reference levels, and as Dr. Reed of the GLC had pointed out (Brighton International Conference, 1975) decisions on Environmental matters had perforce to go on being taken without them. But he wondered who was to set them, and how were they to be checked and enforced? He quoted Sir Winston Churchill who had said, "When you leave the plateau of pious platitude you descend immediately to the arena of heated controversy".

The established method of dealing with Air Pollution in the UK was embodied or even enshrined - in the philosophy of 'best practicable means'. The weakness of bpm, if it had one, lay in the possible failure to maintain plant to a very high standard, or the failure to operate it properly at all times - or both. There was in his mind a possible inference that the drop in the Phase 2 alerts that had been mentioned earlier could well have resulted from a more responsible attitude by a workforce who knew that they stood to be inconvenienced. This supported the contention that much could be done to reduce nuisance from odours - and indeed other pollutants - simply by good housekeeping.

There seemed little doubt that constant vigilance by all involved, great care in granting planning consents and careful reassessment whenever plant or buildings were due for renewal, were all of value in the long term.

Speaking in terms of simplicity versus sophistication he explained that in Derby, Rolls Royce had realised that complaints about noise and the smell of kerosene from their test beds were more likely to arise under inversion conditions. They had accordingly installed a small radar device which gave a continuous chart of inversion levels. They had their own weather station which supplied air pressure and temperature together with wind speed and direction. There was also liaison with the local Meteorological Station at Watnall. Under adverse conditions engine testing was restricted or even stopped, this seemed to him a highly commendable self-regulating system involving the minimum of resources.

He agreed wholeheartedly with Professor Mellanby in his comments about tobacco smoke. Saying that he recalled the discomfort he had experienced, not least at his early Clean Air Conferences, he shuddered to contemplate the production of any cheap safe tobacco substitute if it reeked and choked and stagnated in the way that tobacco smoke did.

He came to his last point about getting on with the job in hand. He remarked that in Derby, for example, he saw hot blast cupolas transformed by the Alkali Inspectorates latest requirements. He saw a new cold blast cupola meeting the requirements of the 2nd Working Party on Grit and Dust Emission. Against that he saw but slow progress in a smoke control programme which had been two thirds completed three years earlier. Given an option at that present time between more specific measurement of pollutants and completing the smoke control programme he would unhesitatingly go for the latter. It provided the prize of a smokeless City, it got out of the way a known source of pollution which had a known and relatively cheap solution; and it would help to reduce some of the hidden peaks on Derby's 24hr daily volumetric smoke and sulphur dioxide measuring instruments. What was the next step? He was sure there was no lack of work to be done nor of activity but the effort was by no means evenly spread. He believed there was a vital need for more co-ordination of who was doing what? where? when? why? and with what results - and of what had national and what had purely local significance. Referring to Mr. Iddison's opening address,he asked him to say more about the co-ordinating body he had mentioned in the discussion to follow.

Concluding, Mr. Raven remarked that it would seem that the control of pollution, like politics, was rapidly becoming the art of the possible. Professor Lawther had told the Conference, in effect, that the less they had the less they wanted! Here was the dilemma. Was perfection being sought in an imperfect world? Was there perhaps at times danger of attracting the criticism that attempts were being made to answer questions no-one had asked?

Professor R.S. Scorer (Deputy Chairman, NSCA), said that in the hotel in which he was staying in Harrogate the bedclothes smelt of cigarette smoke, presumably because the previous occupier had smoked in bed, which he thought a disgusting habit. He remarked that some old age pensioners did it,occasionally setting fire to themselves: the reaction of those who managed old people's homes to that was to spend large sums of public money on very expensive fire-fighting equipment - the assumption being that if there was anything which people might be said to need, or want, attempts should be made to get it. He thought that a philosophy degrading to the human spirit, and while it gave little or no responsibility to the individual to refrain from indulgence of various kinds, it devalued the personality purely in the interest of perserving numbers.

All that had been said about amenity arose almost entirely because there were too many people. It had been said that within living memory one could get out of Sheffield with a tuppeny tram ride into the country: a century earlier one could have done it on foot in 5 or 10 minutes even from the centres of the worst pollution. That was not possible in 1977 mainly because there were more people. The loss of food due to pests and diseases had been mentioned, but the loss due to waste and over eating had not been mentioned: he was therefore prompted to think that it might be silly to bother about pests simply to support waste and still more to support a greater number of people with the consequence that all the problems that had been discussed would be exacerbated. Indeed the social organisation

that had been built up seemed to foster personal irresponsibility simply by seeking technological solutions to everything and not putting the issue squarely before people and relating it to their individual conduct. It seemed that in the pursuit of the greatest good of the greatest number the emphasis had been put on number.

The consequence was that humanity, seen from any non human viewpoint, was a plague on earth. Instead of thinking of people as put there by God to manage the earth, an education was required which helped people to see themselves as a magical product of the environment, dependent upon it for continuance of life. The voles who tried to live within a yard of the motorway did not deserve too much sympathy. They only needed to move a yard or two back from it for the environment to be suited to them - but there was already another vole there, so where was the cause for worry? Surely there were enough voles.

He was all for getting rid of black smoke, but not because people were killed trying to overtake on a narrow road through a cloud of it - people who did that did not deserve sympathy: it was the frustration of the sensible people who did not overtake that needed to be considered. He did not believe that society should aim to protect everyone from their own foolishness, because that would put the damper on a lot of initiative and fun: why should individuals be stopped from some enterprise because someone else might get hurt through their own fault?

Dr. R.A. Barnes (Esso Petroleum) said that he had 2 questions and one comment, the first being a question to Professor Lawther. He had just returned from the first International Symposium on Sulphur in the Atmosphere which had been held in Dubrovnik, Yugoslavia. He thought he spoke for the entire British contingent when he said that they had been horrified at the American paranoia - a word he used advisedly - about aerosol sulphate concentrations. This paranoia had reached such an advanced stage that the word 'sulphate' was used synonymously with 'sulphur compounds'. When questioned, the Americans had admitted that the only proven environmental effect of aerosol sulphates was a reduction in visibility but that they felt sure that a health effect must exist. Dr. Barnes asked what Professor Lawther's opinion was on the health effect of earosol sulphates in general and in the U.K. in particular.

In his presentation, Professor Mellanby had said that he did not believe that agriculture in the U.K. suffered the 15% lossed claimed by Dr. Saunders. Dr. Barnes wondered whether Professor Mellanby had considered the possibility of sub-climax cropping (the growth of a crop which is not the economic optimum for a given location) due to air pollution. Professor Mellanby had also indicated that he believed the loss of lichens in many areas, due to mean annual sulphur dioxide concentrations over 40 mg/m^3 was distressing to environmentalists. Dr. Barnes though that if the population as a whole was asked if it preferred the absence of lichens on gravestones or the fuel and power costs involved in reducing sulphur dioxide concentrations to below 40mg/m^3 nationwide, the answer would be quite unambiguous.

Mr. P. Draper (Individual Member) said that as an engineer who liked to see problems solved in a practical way, he was very pleased to be in agreement with his learned friends. He considered that as usual, Professor Lawther had digested the coverage of the overall situation and as a scientist and researcher into the actual effects of pollution he had differentiated between the real and imagined or feared problems. Professor Lawther had outlined the need for caution in selecting and applying research to avoid needless waste in non worthwhile research; a great deal of which, Mr. Draper agreed, was going on at that time. On the other hand, there were several outstanding problems which still remained to be solved. Mr. Draper was absolutely convinced that smoke from diesel engines could be eliminated almost overnight if the practical means that were available were simply adopted and the legislation was changed to suit. Mr. Draper said that Professor Mellanby had produced a very interesting paper. We he had first read it, he had felt upset that the Professor appeared to state some of the popular and unproven fears in general circulation. But he hastened to add, Professor Mellanby had soon demolished these fears with the result that when he had finished reading, the conclusions, by and large, were that very little damage overall was done by the condemned pollutants, such as sulphur, carbon monoxide, the oxides of nitrogen, lead, and others and that tobacco smoking was the most serious polluting activity at that time. He could not understand how people could bring themselves, not only to breathe smoke right down to their lungs, but to have no consideration for the rest who had to breathe what they breathed out.

Time would not permit any detailed comment so Mr. Draper restricted himself to one only. Professor Mellanby had said that "it would appear that sulphur emissions do not do a great deal of damage in Britain." He wanted that to be quoted often in the presence of the lay anti-pollution community where sulphur emissions were often referred to as 'these poisonous fumes'. In conclusion, Mr. Draper made a very strong appeal to the gentlemen of the press, not to quote the damaging statements in Professor Mellanby's paper out of the context which generally refuted them.

Dr. A. Parker (Vice President) said he realised that unusually high amounts of oxides of sulphur in the air greatly affected persons suffering from severe bronchitic disease and were not pleasant for other persons. Persons in very good health, however, seemed to withstand relatively high concentrations of oxides of sulphur for a short time without harmful affects. During the first world war, Dr. Parker had had the task of inspecting and analysing samples of TNT made at a factory a few miles from Birmingham and deciding whether large amounts of batches of TNT were of the quality to be sent to shell-filling works in various parts of the country. The TNT factory had been built hurriedly with no consideration of the affect on the environment. On arriving at the nearby railway station the oxides of sulphur in the air were so great that he had coughed for about a minute and was afterwards not affected. He had probably breathed more oxides of sulphur and sulphuric acid than any of the delegates at the conference, but was still in good health at an advanced age.

Mr. R.V. Redston (C.E.H.O. City of Bath) had two questions for Professor Lawther. He said that in the afternoon's paper, Eric Foskett had quoted the strikingly improved figures for sunlight in the Manchester area. He asked whether Professor Lawther had any comments on the health value of that benefit, as most would see it, from clean air. His second question related to epidemics of what were lightly dismissed as the common cold and influenza which were experienced every winter, or nearly every winter. It was known that basically those were viral infections; he asked whether any work was going on to establish whether air pollution was a pre-disposing factor.

Mr. L.E. Robson (Assistant Chief E.H.O., City of Bristol) referred to Professor Lawther's mention of the importance of geographical pathological statistics, which had to be studied when setting standards and air quality criteria. He asked whether any of the speakers could give Conference advice on how local authorities could obtain such statistics, which in his experience were not forthcoming to local authorities when they were studying local problems, numbering results and giving advice to local communities who had asked specific medically orientated questions. As he saw it, the problem was worsened by the Area Health Authorities' not having been given the same geographical boundaries as local authorities, or the staff, resources or drive to check such aspects.

Mr. S.J. Garrod (Chief Environmental Health Officer, City of Oxford) wished to make two comments to the discussion. One was about bonfires. Whether in his part of the country they had a greater number of fire raisers or not, he did not know, but he thought it was still a difficult problem and he wondered whether the answer to it was a better educated public or whether some tightening up of the Clean Air Act, 1956, Section 16, was required. He was amazed by the number of people who in urban areas like his own still went down the garden, pulled up green weeds and tried to burn them immediately thereby creating a considerable amount of smoke to the detriment of their neighbours. He did not know how other delegates coped with the problem but, in his part of the country, they received a considerable number of bonfire complaints which were sometimes difficult to deal with.

The other comment he wanted to make was with regard to the black smoke from vehicles. He thought it was recognised, particularly in London where a considerable amount of work had been done on the problem, that a lot of the particulate matter that was found on the daily smoke filter stains was now coming from vehicles. It was not coming from the old domestic fires where smoke control was in operation. In a city like his own, where they had spent actually millions of pounds cleaning up buildings of which they were very proud, it seemed they were going to be in the position, if they were not already there, where they might have all their wonderful buildings blackened again because of the black smoke from vehicles. What worried him was that there were the Vehicles (Construction and Use) Regulations but if the number of prosecutions that were being taken by the Police who implemented them were to be checked, it would be found that they were very few and far between. He knew, everyone knew that the Police did a wonderful job but they were not atmospheric pollution minded. That had to be accepted.

Environmental health officers were so minded, and were at grass roots level; the Police were not at grass roots level to the same extent, unfortunately they were much more thinly stretched on the ground than had been. He wondered why it was that Local Authority Officers had not been given the opportunity to deal with black smoke from vehicles. Professor Mellanby had mentioned such vehicles in Mauritius; there were a large number in the U.K. also that needed, he suggested, some attention with regard to cutting down the emission of black smoke. He asked for Professor Mellanby's views on dealing with vehicle black smoke and smoke from bonfires.

Mr. N.K. Das (Department of Health & Family Planning, Govt. of Assam, India) said that as he had been listening to the discussion, two questions had occurred to him. He did not have any specialist knowledge and did not wish to rush in where angels feared to tread. However, he pointed out that in the underdeveloped countries, it was difficult to make epidemiological studies. As Professor Lawther had pointed out, there were epidemiological as well as experimental studies which would have to be made about the effects of a pollutant on health. He therefore asked Professor Lawther whether experimental studies would be more useful or economical for underdeveloped countries, since underdeveloped countries were so vast and inaccessible. Under such circumstances, he felt that epidemiological studies might not be as wide and comprehensive, and in that case felt that experimental studies on the effects of pollutants would be more economical and more useful.

Another point Professor Mellanby raised was that in the UK, the effects of air pollution upon vegetation would not be very great; but Dr. Saunders had pointed out that there would be a 15% loss of vegetation. In his country, Mr. Das had found that due to air pollution, the Assam vegetation had been affected to a great extent. He explained that India was a major tea producer, particularly in the Assam, north eastern, region of India. In this part of India, the tea could be affected by the fertilizer industry, which gave rise to sulphur fumes; these would be washed out as sulphuric acid by the rains and these rains would fall on the tea crops, so that the good teas would be affected.

Mentioning another way in which Indian vegetation might be affected, he cited the silk industry, in which the silk worms fed on mulberry plants: and silk worm industry could also be affected by the burning of methane gas which came out of the well used in oil exploration. He asked Professor Mellanby to throw more light on whether this would affect vegetation to a great extent.

Mr. R.W. Wakeley (Commonwealth Smelting Limited), commenting on two points made by Professor Mellanby, said first that in contrast to theories such as those that had been mentioned by Professor Saunders later in the programme, Professor Mellanby had felt that loss of agricultural crops in rural districts by sulphur dioxide pollution was not measureable or minimal in comparison with effects such as bad farming methods. Mr. Wakeley concurred with this since, working in a heavy industrial area where corresponding SO_2 values had occurred, it was clear to him that the limiting effects on neighbouring crops were due to such factors as waterlogging, deficiency diseases or poor farming practices. However, both industry and local

authorities could be partly responsible for poor farming since, by buying up land for development and then not developing it, tenant farmers then had no real incentive to get the best out of their land under conditions of uncertain tenure; where there was urban encroachment it was the farmers who lost out on amenity value. His second point related to Professor Mellanby's comment on the fact that some economists talked nonsense about pollution control. One economist who did not do this was Professor Wilfred Beckerman. His book "In Defence of Economic Growth" (Jonathan Cape 1975) was a refreshing and optimistic counter-blast on the whole subject and worthy of delegates' attention.

Dr. B. Leadbeater (Individual Member) was pleased that Professor Lawther had once again come to the conference to do quite a bit of de-bunking. He had pointed out the peurile basis for many of the official standards and criteria of the World Health Organisation, and other agencies, for air pollution concentrations. He wondered who could deny the sheer logic of what Professor Lawther had said of his approach and wished that the paranoiacs would take more notice of him. However, having endorsed what he had said in that way, he was left with a rather fundamental question which he wanted to put to him. It was how could it be determined at that very time, at what point people should stop spending and emptying their pockets to reduce pollution in an attempt to obtain indefinably 'clean' air.

Mr. D.E. Luke (London Borough of Southwark) explained that he was attending his first clean air conference and was rather interested in the anti-smoking lobby. He considered himself to be an expert, in that, like many people, he was a cured addict. He thought the problem about smoking was that a smoker failed to realise just what a revolting habit it was. Certainly his father-in-law, who came to stay with his family from time to time, had no awareness that his 40 a day caused all sorts of problems in his son-in-laws' house. Mr. Luke wished to see each non smoker issued with a special smokers' kit, which would consist of an old fashioned stink bomb and a pack of cards to go with it, and a message saying "this is what your cigarette is doing to me". The non smoker could then squeeze the stink bomb, there would be a revolting smell and two advantages would occur. He thought it would really get home to the smoker just how revolting his habit was and it would make him go away. It had, of course, one disadvantage, in the problem of odour that Professor Mellanby had referred to. Mr. Luke realised his idea was a bit whimsical, but as the television campaign showing a rather delightful young lady with bad breath from smoking, seemed to have failed (since when he went to a party young people seemed to be smoking as much if not more than ever), he wondered what could be done to persuade people who smoked, just how much they smelt and just how revolting the habit was.

Mary George (Electrical Association for Women), said she had noted that a previous speaker had referred to the American attitude towards aerosols. That, she thought could become a very emotive subject in the U.K. She felt it would be interesting to have a few comments from Professor Lawther and Professor Mellanby on the subject. As she understood it , in the USA the official position was that if there were any suspicions of a hazard caused

by a particular product, the product was banned. Whereas in this country the view was taken that as much as possible should be found out about the likely hazards and then means should be sought to control those hazards. That would seem to be a much more healthy approacn to the subject, rather than, to para-phrase the old saying, 'Find out what little Tommy is using and tell him not to use it'. Aerosols were products which were used in every home and in a considerable number of gardens in the UK and it was desirable to know a little more about what hazards were before following the practice in the USA and starting to ban them.

Mr. T. Iddison (Chairman) referring to Mr. Raven's wish for some comment in connection with monitoring, said that what he had probably been referring to was the Air Pollution Monitoring Management Group, which had been mentioned during his speech at the Opening session. It had been set up by the Department of the Environment, following the publication of their document on pollution control produced by the Central Unit on Environmental Pollution. The organisation thus referred to, was such that represented on it were most central government departments which had any interest in air pollution at all, local authority representatives from the local authority organisations and of course representatives from Warren Spring Laboratory. There was a steering group that met four or five times a year and in due course he was certain that it would be publishing some of its findings. It was certainly trying to rationalize monitoring and AERE Harwell were also represented there. To anyone with an interest in it, he suggested that they could obtain further information by writing to the Secretary of the Air Pollution Monitoring Management Group at the Department of the Environment. Mr. Iddison then allowed time for Dr. Barnes of Esso Petroleum to add a few words to his previous comments.

Dr. R.A. Barnes (Esso Petroleum) wished to elucidate his earlier reference to aerosol sulphates. The concern over aerosol spray cans, to which Miss George had referred, had nothing whatsoever to do with sulphate or any other variety of aerosol. An aerosol was any micron-sized particle suspended in the atmosphere. The interest in deodorant and other "aerosol" sprays was related to the propellants used - chlorofluorocarbons - and their possible effect on the ozone concentrations of the upper atmosphere.

Professor P.J. Lawther, replying to the discussion, turned first to the question from Dr. Barnes about the reason for the current US concern or even paranoia about sulphates. Professor Lawther thought it was an extraordinary phenomenon. Historically, he supposed there had been a reasonable basis for it when, in early experimental work, he and his fellow researchers had failed to get any measureable effect from sulphur dioxide it had seemed very reasonabl to do an experiment in which they could increase the concentration of the sulphur compound at the site at which it might be effective. So instead of breathing a gas at the very low partial pressure of 1 part per million, they had wondered whether they could make it fire off receptors by concentrating it, and obviously the best way to do that would have been to oxidise it to sulphuric acid. They had failed to get an effect largely he thought because when they inhaled sulphuric acid the droplets rapidly diluted so that by the time it hit the receptor it had been already very dilute. Many years ago, someone had suggested that zinchydrogen sulphate might have been the "toxic agent" in the 1952 "smog"; this was because the Danora episode involved a zinc smelter!

They had tried to make a more stable aerosol of sulphuric acid; to wrap it up in smoke or even protect it with a monolayer to see if that would be more effective. All the attempts that he knew of to do that had failed. In rat work and guinea pig work Mary Amdur had produced a 'League table' of the irritance of sulphates and of course, not surprisingly, it was related to their hydrogen ion concentration. All the human experiments that he had done (and as he had said they had gassed themselves till they had been almost crystallized), had shown no effect of sulphate, but there remained of course a very important possibility that there was within some narrow band, of temperature, humidity, oxidation potential, a droplet which would enable the pollutant to hit an effective part of the lung. But this was nothing to do, he ventured to suggest, with the present American concern about sulphates. It arose from the CHSS programme which was a panic measure epidemiological exercise into which literally millions of dollars had been poured. The American measurements of pollution had been so behind U.K. techniques that it was barely credible. They had still been using the deposit guage; they were still using the lead peroxide candle which was an excellent method for measuring corrosion of buildings; they had been using the high volume sampler which samples particles which are far too big to get into the lung. When they had stoked their computers up with all the rubbish that they had been able to collect from days gone by from their rather antique measurements, they had obtained correlations with SO_2 but a better correlation with sulphate, but it had not been cause and effect, it had been merely a reflection of the inadequacy of their measurements of SO_2. Experimentally they had produced nothing relevant.

Mr. Philip Draper had made a most important point at the conference in mentioning the power of the press. Professor Lawther had often wondered whether it would be possible, epidemiologically, by refining the techniques to assess the morbidity and mortality caused by some of the alarming items in the press. As a physician he saw the end result of that and saw much suffering caused by alarm. But he wondered if people were not themselves to blame. He had been brought up by his old professor to make friends with the press, make himself accessible: if people did not, they got what they deserved; as a result, he thought that only once in the previous 22 years had he been maliciously wrongly reported. He wondered sometimes whether it was not the "toffee-nosed" attitudes to the press which had to be revised.

Referring to the health effects of increased sunlight, he said that incredibly enough, there were people who bellyached about that. Manchester had been cleaned up; it had been shown to be sunnier and then people said that skin cancer could be caused as a result! The mind boggled. He really thought that the concern about that was too absurd to be taken seriously.

He had been asked whether air pollution was a factor favouring virus infection. He wished he could answer that question. He and his fellow researchers had isolated from coal smoke, a factor which had influenced, even promoted the growth, they thought, of haemophylis influenze, a bacterium which was present in the sputum of patients with bronchitis; they had thought they were on to something. It might only have been an indication that they had been neglecting the effect of air pollution on micro organisms. He knew of nothing of the effect on viruses. It might mean that the host's ability to conquer viruses

could be affected. There was some vague work in the literature that some pollutants, especially nitrogen dioxide if there was enough of it, could alter the immunological competence of the body to deal with micro organisms and that might well be one of the most important lines of research.

Dr. Parker had asked whether food was the major source of lead. Professor Lawther belived that food and drink were withouth doubt the major source of lead, he could accept Arthur Chamberlain's rough assessment, on experimental work, that one microgram per cubic metre of lead in the air could, if equilibrium was achieved, be responsible for contributing 1 microgram per hundred ml. of lead to the blood. That, living and working as he did in the centre of London,could contribute 2 micrograms per cubic metre per 100 ml. of lead to his blood and he felt that to be really very small in comparison to the amount conributed by food and drink. He thought that often the variability of blood leads that could be seen was a reflection not merely of differences in diet but differences in cultural habit. He explained that there was a rare disease of babies, due to nitrites interfering with the haemaglobin in the blood; they got navy blue and an interesting conundrum arose: Mrs Snooks and Mrs Brown, next door to each other, both with 5 months old babies, one was navy blue and one was nice and pink, as it should be, and they both had almost exactly the same living conditions. This methaemoglobinemia was due to nitrates in the water; they both had the same plumbing, but one mother emptied the kettle before she refilled it and the other did not. So eventually, she got a nice nitrite soup. If cne considered the habits of the people who had higher blood leads than others it might be found that their wives did not empty the kettle before making the morning tea. The answer was often quite simple.

Geographic pathology: Mr. Robson had asked where to obtain the statistics for geographic pathology, Professor Lawther would have made the DHSS produce them but he warned Mr. Robson that before he set his sights on getting anything, he should not forget that locally it was unlikely that he would see any startling correlations if he was studying diseases as common as chronic bronchitis. But there had been an ENT surgeon who had gone to live and work in in High Wycombe and she had been taught, very properly, that adenocarcinoma of the nasal sinuses was a rare disease. She had begun to wonder why then she had seen 5 in her first year of practice, and of course it hardly needed to be said that it had been her work, her alertness, which had resulted in spotting that in furniture workers, working with wood, there was an excess of adenocarcinoma of the nasal sinuses and it was now a prescribed disease. It was lucky that mesothelioma in relation to blue asbestos was a very rare tumour and therefore if a doctor found more than one or two of them together in the same place his work was made easier.

Professor Lawther thought that Mr. Das had been entirely right about the difficulty in applying epidemiological methods in developing countries. Many people, in the days of controversy about the relationship between lung cancer and smoking, had pointed to the need to look at the mortality from lung cancer in say, Turkey, where they smoked different tobacco. He had gone to Turkey to look at one or two problems there. If somebodys' uncle had died he would have needed a friend with a shovel, not a death certificate, and therefore the application of epidemiological techniques was dependant upon the existence and quality of accurate certification. That did not mean epidemiological work in developing countries had to be abandoned,

he could give a list of work where astute clinical observation had lead to the identification of pathological factors, one only needed to look at Barkett's lymphomia in Africa, the identification of alphatoxin by observing that turkeys eating mouldy peanuts got evil growths in the liver. He thought it was mostly a question of astute observations and then following them up.

Dr. Leadbeater had asked how ought what the public paid be assessed. This was the key question. He had been asked a few days previously about the siting of an old people's home in Croydon. They had had two possible sites. One virtually on the Brighton Road, the other about 300 yards up a slight hill, away from pollution by traffic. There had been no question about it in his mind; he would have picked the one on the Brighton Road purely because the 300 yards had been uphill; it had been much further from a bus stop, much further from the Post Office where the old people would go to collect their Pensions. He thought that probably education was most important; also the presentation of some quite remarkable facts. He had been talking to a colleague not long before, who had lunched with an advertising executive who had been handling the account of one of the major tobacco firms. In 1976 the money spent on advertising tobacco had been £85,000,000 which made some of the MRC's budgets look a bit stupid. But he had produced a figure which had helped Professor Lawther to educate medical students; he had said that tobacco companies backed off a certain amount of money for every doctor who smoked (and for "doctor" could be read clergyman, schoolmaster: people who would have been expected to behave sensibly); the figure which a smoking doctor saved the tobacco advertising people was a staggering £50,000 a year. He thought that it was a sober presentation of that kind of fact, rather than condemnation of the smoker, which might produce results.

Miss George had asked the final question. Dr. Barnes had mentioned the distinction between the American concern with sulphates, and their concern equally with the so-called aerosols. Professor Lawther thought that much confusion arose from the abuse of the word "aerosol". He explained that aerosol was a specific term which meant a colloidal suspension of particles in a gas and he though people neglected, in their concern with the possible cosmic effects of the stable propellants, the possible dangers of spraying the actual aerosol about. He had been involved in a hunt not long before for a disease which had been christened thesaurosis, storing up hair laquer in the lungs. The amount of polyvinylpyrrolydon or shellac that could be inhaled in a hair spraying saloon was quite phenomenal and he would have thought that the concern about possible long term effects of the very stable fluoronated hydrocarbons might obscure the need to look more closely at what were the effects of inhaling spray-on starches, deodrant sprays etc.

Professor Mellanby, replying to the discussion, said that Professor Lawther had given him an idea. If they were both feeling hard up perhaps they could approach the tobacco industry and ask how much the industry would be willing to pay them if they pretended to take up smoking. A number of interesting questions had been raised in the discussion. Dr. Barnes had brought up the question of whether air pollution, although not likely to harm many crops in favourable areas, could prove to be the limiting factor if a farmer wanted to grow a particular crop in a particular area. Professor Mellanby thought that if one was situated near to an aluminium smelter one wouldn't

keep cattle on, so he considered there were such cases. He would be very doubtful about growing tobacco in certain parts of the world. It was known that there were parts of the USA where a variety of tobacco, which was particularly susceptible to oxidents, was affected by a combination of the climate and automobile exhaust gases. In the UK, this type of damage was more likely than had been thought. Those who in 1977 had grown a particular susceptible variety of tobacco, Bell W3, had noted that during hot weather they had had quite considerable necrosis of the leaves which was almost certainly due to oxidents. The tobacco variety Bell B, a commercial variety, when grown alongside the susceptible variety, exhibited no lesions under UK conditions, so the situation was not serious but it did show that there were possibly places where very susceptible crops in particular were being affected. He repeated what he had said earlier on that from known levels of UK pollutants over the main agricultural area, it would seem to him that the levels were far below those at which any type of cryptic damage could occur.

Mr. Das had referred to problems that might arise in the tea gardens in Assam. Professor Mellanby did not know exactly what the pollution was likely to be there; Mr. Das had mentioned sulphur from fertilizer factories. He did know that camellias were very susceptible to a number of pollutants, and that they could be used as an indicator species in urban areas to measure pollution. He explained that tea is a camellia, one did not put it in a button hole, but in a tea pot, but still it is the same group and it might well be that tea which normally was grown in particular areas would be damaged if a massive industry was developed. He would have expected tea to be one of the crops that grew best under pure air conditions.

Mr. Garrod had spoken about bonfires. He felt a bit guilty about this because he himself lived in the middle of the country. He had lit four bonfires a few days before, simultaneously. He did of course also put everything he could on to compost heaps but there were things that it was really easier to burn, as he had rather a lot of ground; it was rather difficult to get rid of woody refuse. He did, however, agree that bonfires created problems in more congested areas where there were neighbours likely to suffer, whose washing also suffered. The only bonfires he himself suffered from were the burning of straw in wheat fields and this had caused him considerable annoyance in previous years. He had had to re-decorate parts of his house because of the smuts from the burning of straw by his farmer neighbours; that could be a very considerable source of air pollution in some areas. Then the problem of diesel engines had been mentioned and it seemed to him that this was an easily solved problem which was not being satisfactorily dealt with. One only had to drive along a road, on any day of the week, to see unnecessary black smoke being poured out by lorries and buses and this could provide the hazard, mentioned by Professor Scorer, of driving through it with the chance of having a head on crash. He thought it was something everyone would like to see stopped and if the present system did not allow those who were the most suitable people to bring action, the law should be changed and this was the sort of thing that he considered the NSCA ought to take up.

He had spoken about economists. Economists were of all kinds; he commented

that it had been said that if all economists were laid end to end they would each have a different solution, and this he thought, was partly true. There were two points of view put forward by economists which were relevant to the discussion. There were those, as he had said, who had suggested that it was always going to be terribly expensive to control pollution and sometimes that was true. There were also those who had taken as a whole rather optimistic views about the future. He agreed that Porfessor Beckenman's book was one that should be read in conjunction with many others. He did not feel that he would take it as being canonical literature; he would also commend several other books, for instance, "The Next Two Hundred Years" by Herman Khan. He disagreed very strongly with Herman Khan on a number of points; he thought he often talked nonsense, but he equally thought that Khan frequently talked quite a lot of sense. He also thought that a recent book produced by Professor Scorer called "The Clever Moron" was one that gave, in very lively form, a good deal of extremely useful information on many of the subjects that Conference were interested in. He thought that reading Porfessor Scorer's book would give a great deal of wisdom to all, but he thought knowledge would be even greater by wider reading of the different points of view of various environmental subjects.

People were always worried that there was cryptic damage going on that they did not know about. He believed that some of the more extreme environmentalists would say that it was well known that the world was becoming mo e and more polluted all the time and when it was pointed out what had been done to cure it and it was shown that there were many improvements, would agree that these benefits might have occurred, but would ask what was being done about all the other things, the damage from which was not yet know. Professor Mellanby though this attitude absurd in some ways,but not completely. It did mean that the important thing was eternal vigilance It was necessary to be on the lookout.

Nobody ever thought that polychlorinated biphenyls were likely to be a source of damage to either man or wildlife and the cases of proved, serious damage in Britain were not very great. There had been cases in Japan and elsewhere, where PCB's had got into the environment in quantities that had been lethal to human beings. This had not occurred in the UK. All people contained polychlorinated biphenyls from industrial production in their tissues in very small amounts. They contained also DDT and all sorts of other things in very small amounts. In the laboratory of which he had at one time been director, it was found that levels in certain forms of wildlife were rising rapidly to within the order of magnitude where one might expect damage to occur. In that particular case, the industry, Monsanto Chemical Company had collaborated extremely well and many of the possible dangerous uses had been brought to an end, and the levels had started to fall and serious damage was avoided. This would happen again; there was no doubt, that as new industries were developed, mistakes would occur which could not be avoided, even when people were being careful.

In developing countries there was the urge to become more prosperous or to produce more (which was not always the same thing) more effort might be put into growth than into preserving the environment. It was necessary to see

that those were not serious developments; they had to be acted upon, but at the same time people ought not to be so paranoiac that they assumed that every new development was necessarily damaging the environment. It was known that a lot of them were not, it was known that some of them were. Those were the sort of things that had to be looked at.

He agreed with what Professor Scorer had said about population, it was obviously in the long run going to be mankind's most serious problem, but it was not one that the NSCA had a direct remit to cure. He was also worried that people were getting so paranoiac about certain types of danger. Attempts were being made to nanny the population in a way that he though was quite unnecessary and it was very unhealthy.

Because of new legislation, research councils were setting up working parties to draw up a code of conduct for ecological workers who were engaged in field work. When he had been lucky enough to be paid to do field work, it had been rather similar to what some people did on a Sunday walk catching butterflies or bird watching. That had been jolly dangerous of course, he could had got his feet wet, he could have forgotten to put on his woollies or forgotten to wear a mackintosh or a hat. He could forsee a Government regulation saying that any government official who did field work must do the following, and by the time that he had complied with all that it would be the end of the working day and he would not have gone out and done any field work at all.

Clearly, it was wrong that anyone should be burnt to death in an hotel, but he wondered what proportion of people had been seriously injured when hit by one of those revolving doors that have springs that hardly move when one is carrying luggage because of a risk which really must be minimal compared with that from motor cars, smoking or other things that people faced.

Professor Mellanby concluded telling a story about the dangers of safety precautions. His tractor driver, on the first day of European Farm Safety Week, had driven his tractor rather too quickly over a "sleeping policeman" that had been made in order to make it safer in his yard so that people could not have traffic accidents. He had bumped on his seat, forgetting that the day before a safety cab had been fitted to his tractor, and he had had seven stitches put in his head as a result. As could be seen, safety could often be awfully dangerous!

WHAT HAS BEEN ACHIEVED AND WHAT REMAINS TO BE DONE - IN THE DOMESTIC FIELD
E.W. Foskett
Director of Environmental Health, City of Manchester

THE FIFTH REPORT OF THE ROYAL COMMISSION ON ENVIRONMENTAL POLLUTION - COMMENTS BY THE CBI.
A.I. Biggs

Mr. C.R. Cresswell (Principal EHO, Newcastle upon Tyne MBC), opening the discussion, did not expect that Mr. Foskett had anticipated that everyone would agree with the views he had expressed, and thought in fact if they had it would not have been a very good conference paper. Mr. Foskett had asserted that to entrust the task of pollution control to L.A's was right and to some extent where there had been a minimum of effort put into introducing smoke control, it was justifiable to blame a lack of persistent pressure from the central authority. This brought up again the points made at the Edinburgh 1976 Conference, in the discussion after Mr. Batho's paper. One could not argue for local control and freedom to act and then when it did not work expect the Government to interfere and provide central direction. Whether it was right to put responsibility for controlling pollution with district Councils had been, and to some extent still was, important. The West Bromwich Borough Council, for whom Mr. Cresselll had worked prior to re-organisation, had been one of the few authorities to fight hard to get all pollution control put at County level. Control under such circumstances might well have been more uniform and the need for direct involvement by Central Government HMPI, minimised.

He felt that the need for a national fuel policy was obvious but it had to be conceded that any plan had to be so flexible, to take care of new sources of energy, new technologies and techniques, political and economic changes etc., and so variable, that the chance of the policy turning out to be correct was remote. However, that did not detract from the advantages of any fuel policy taking into recognition the importance of clean air.

Mr. Cresswell thought that there would be considerable advantage in linking fuel pricing to pollution control: for example it would be advantageous if the costs of reactive solid smokeless fuels could be more closely related to the price charged for bituminous coal. Everyone was aware that burning reactive fuels in an approved appliance was thermally more efficient than burning coal on a stool bottom. But when it came down to the average householder, who, as a result of Circular 54/76, had to burn reactive smokeless fuels on an improved open fire, on which he had been burning coal for many years, he simply found his fuel bills had rocketted out of all proportion to the advantages he saw clean air bringing to him. For this reason he wished to see the reactive fuels subsidised by an increase in the price of coal. In that way, smoke control would receive a welcome boost in the many areas where it was badly needed if, even at that late stage, the NCB were to be more generous in the supply of smokeless fuel to replace concessionary coal. The cause of clean air would also be served if there was to be a reduction in rateable value when a householder installed smokeless appliances or had his property insulated. Use was being made of the Job Creation Scheme in some areas to make progress. Council house tenants were having their bedroom ceilings insulated free of labour charges, the materials having been bulk

purchased and supplied at advantageous prices.

Returning for a moment to 54/76, Mr. Cresswell said that the Circular had caused considerable problems and was a constant source of irritation to householders affected by it, particularly in areas like Newcastle where they were nearing the end of the programme. People could not understand why friends or relatives a few streets away had a grant for replacing an approved open fire in 1976 while they themselves were refused one in 1977. As that type of appliance relied entirely on reactive smokeless fuels it was to be hoped that the NCB private manufacturers would ensure that ample supplies were always available, something which had not always been the case even when there had not been the numbers of appliances around which there will be in future years.

Smoke control areas had and were still having rapidly reducing concentrations of smoke but in Newcastle, as he believed was the case in other urban areas, they were reaching an apparent watershed in SO_2 levels. Between 1961 and 1974 SO_2 concentrations there had fallen by 55% but in the 3 years from 1974 the reduction had only been 7% in spite of an accelerated smoke control programme. There were a number of possible explanations for that which were currently being investigated but the reason was not obvious.

He did not agree altogether with Mr. Foskett when he had claimed that the economies of reduced pollution had been learned by industrial and commercial firms. There certainly had been a massive reduction in visible emissions of smoke but the same could be said of other pollutants. Over many years he had been involved in numerous exercises where the thermal efficiency of combustion plant had been measured and found to be well below what could be achieved with reasonable maintenance. As a result of the inefficiency, emissions were frequently much greater than necessary.

If Mr. Foskett was correct in that public expectation in respect of pollution control was rising and cleaner air was desired by more people, Mr. Cresswell thought that surely local authorities ought not simply give up the ghost when money was tight, believing that further progress was impossible and blaming the Government. The desire for clean air should be kept alive by all means in their power and householders encouraged to proceed with adaptations in their own and everyone else's interests. Believing this he obviously could not agree with Mr. Foskett that central government assistance towards staff costs was necessary in addition to grants. Authorities like his own who had virtually completed programmes regardless of the difficulties would strongly resent such a precedent being set. In any event smoke control did not always require large numbers of staff; it was surprising how many thousand dwellings could be dealt with annually by a single Inspector and a few technical assistants.

Mr. Foskett's experience under Section 12 of the 1956 Act was at variance with his own. The Department of the Environment had advised his authority that they should endeavour to close their accounts for an area 12 months after the operative date, something they had been glad to do in the interests of administrative efficiency. Prior to finalising the accounts (which had for a variety of valid reasons occurred on occasions well after one year), the Department of the Environment had not shown any interest in the service

of notices.

Little reference had been made to bonfires which Mr. Cresswell thought were another form of pollution worthy of attention. It was rarely possible to prove nuisance with garden bonfires and yet during summers like the one enjoyed in 1976 they gave rise to considerable discomfort to chronic bronchitics and the like, particularly late at night. The best answer to the problem appeared to be to have a cleansing service whereby all unwanted materials including garden refuse were removed on request without charge. So far as industrial or trade bonfires were concerned, Mr. Cresswell's Department often had difficulty in that the person responsible for the bonfire and the dark smoke was not the occupier of the land. As an authority they had been, and still were endeavouring to get Section 1 of the 1968 Act amended to make the person by whose act, default or sufferance the dark smoke arose, responsible for the offence.

One of the points made in the 5th Report of the Royal Commission had been that full coverage of an L.A. area by smoke control should not be seen as an end in itself. This was something which he thought many people, including himself, had been guilty of. Attention had been drawn particularly to the burning of wood in rural areas. This was not, however, a problem limited to truly rural districts. On the outskirts of Newcastle when they had come to make their last Smoke Control Order, they had found a farmhouse with ten adjacent cottages situated in woodlands belonging to the farmer. The farmer for many years had used dead beech and oak trees which existed in profusion both to heat the farmhouse and some large commercial greenhouses, while the cottage occupants, not all employed on the farm, were permitted as much dead timber, free, as they desired. If the Council had not included an exemption in the Order permitting the burning of timber from the woodland by those householders, providing it was carried out in such a way as to minimise the emission of smoke, they would have been faced with objections or the timber would have been disposed of by wastefully burning it in the open and possibly giving rise to nuisance.

He considered that although many of the larger and better companies no doubt had the know how to reduce emissions to a minimum, in general the standard of maintenance was abysmal. It was commonplace, for example, to find cold blast cupolas with distorted baffles or partially blocked sprinklers, defective bag plant attached to shot blasting equipment, emissions of odourous compounds from chemical plants due to careless venting, coke ovens with leaking doors due to distortion or inadequate cleaning before replacement and so on. The usual excuse given was that when business was poor the maintenance staff, as unproductive, were the first to be made redundant and when business improved there was no time to stop production for maintenance work. However, the supervision exercised over maintenance and routine work was often very poor and that in his experience was the most common reason for those unnecessary emissions which occurred too frequently.

So far as suspended lead in the atmosphere adjoining motorways was concerned, Newcastle's experience had been similar to that of Bristol. They had monitored adjoining their CME for many months before it had been opened to traffic and the results obtained since it had been brought into use had not shown any increase in lead concentrations.

Finally, Mr. Cresswell referred to a point from Mr. Biggs' paper. He said that zoning to keep industry and residential development entirely separate, although ideal, was impracticable. The cost of travelling to work alone made it vital that people should learn how to build into industrial development sufficient safeguards to minimise emission, whether these were chemical compounds to the air, or noise. He regretted the lack of time to talk further on this subject, as he believed it was of vital importance.

Mr. I. Holmes (High Peak B.C.) had listened to both papers with interest and as one speaker had represented the views of the local authorities making up the Greater Manchester Conurbation and the other speaker the views of a major industrial concern, he felt it would be remiss of him not to take the opportunity to seek their views on a question of fundamental importance in relation to the future control of air pollution in the United Kingdom.

Referring to sections 79-83 of the Control of Pollution Act 1974 relating to information concerning atmospheric pollution, he said that amongst those powers was the discretionary power for a local authority to serve notice on an industrialist - concerning details of their emissions to atmosphere - and to publish the returns of those notices in a register, open to public inspection.

The Royal Commission's Report had mentioned "the need for an increased flow of information to persons of responsibility - who can use it for the ultimate benefit of the environment". An attempt to define "persons of responsibility" had been made in paragraph 18 of the Report of the Working Party of the Clean Air Council published by H.M.S.O. in 1973 - amongst those "persons of responsibility" had been included research workers in universities. A further recommendation in paragraph 28 of the latter report had been that INDEMAT Committees (Industrial Emissions to Atmosphere) be set up by local authorities, to be composed of elected members of the Local Authority in equal numbers with representatives of industry - together with some members of the public (presumably "persons of responsibility"). Amongst the duties of the INDEMAT Committee would be the power to collect, consider and publish information concerning industrial emissions to atmosphere. Although he had to speak briefly, he had given delegates what he believed were the facts behind the most damaging piece of legislation ever to appear on the statute books in relation to atmospheric pollution - namely, the Control of Pollution Act 1974, Sections 79-83.

He said that action groups, civic societies and pseudo environmental organisations persistently petitioned and pressurized Local Authorities to implement those provisions. Most local authorities were well aware of individual industrial emissions within their boundary and had been for many years. However, Action Groups frequently composed of university research workers, lecturers, people who had failed to gain election to the local authority through the ballot box and including many cranks, persisted in twisting the truth concerning emissions to atmosphere and their predictions of doom were made to the delight of an ever waiting national press.

It had been said that Civic Action groups were the C.I.A. of the Tory controlled councils. He himself worked for a Tory controlled Council which was forever attacked by a multiplicity of misguided action groups, composed

in the main of the type of persons he had already mentioned.

He believed any authority which implemented those discretionary powers would drive away prospective industrial developers. In a time of high power politics in Local Government he could not conceive a Local Authority giving away power to local Committees or other ad hoc groups.

The Action Groups, in his experience, were composed of mischievious and destructive people who made up the vocal and vociferous minority to the detriment of the unfortunate majority. He also believed that the general public were adequately represented by their local Councillors.

From Mr. Foskett, he sought an opinion of what the authorities, making up the Greater Manchester Council, had done to implement sections 79-83 of the Control of Pollution Act. Of Mr. Biggs, he asked what advice he would give to his company if a Local Authority chose to implement these regulations. And, finally, addressing both speakers, he wondered whether they would care to comment on the statement "that the release of even the most simple details of emissions to atmosphere may well be misinterpreted by the general public assisted by Action Groups - and eventually frighten away prospective industrial developers."

Cllr. D.F. Haynes (Mansfield D.C.) felt compelled to speak because he believed that there was a complacency at the conference and a complacency nationally as far as smoke control was concerned, and that it was high time that local authorities woke up to the situation. He believed that the Society had done a first class job over the years and the members that had represented the regions at national level over the years had done their job in a proper manner. He had been coming to the clean air conferences for a number of years and in the previous few conferences, he had been disappointed in the amount of work that was being done in that particular field and thought it was no use using the argument of finance to cut out the question of smoke control. That did not wash and did not work. He assured delegates that he belonged to a local authority that was caught up with inflation like everybody else but they continued with a smoke control programme, which he though was quite right because it affected the health of the community that the council represented.

He had heard one or two things said that day by previous speakers about certain regulations. He believed that there was never any problem about their implementation. In particular he referred to comments about the way in which the police did their job as far as road accidents were concerned; there were, he pointed out, road safety committees on local authorities to do a particular job, to try and sort out the accidents that took place, with a view to road safety. Money could be spent in that direction, and money could be spent to enable the police to do their job as far as prosecution was concerned. There was a first class department that could implement the instructions of the district council as far as smoke control was concerned. He thought it was not a question of getting hold of a large area and going to town in that way, but his council felt that if they gnawed away at the problem they were making progress all the time and doing the job that they had been put there to do.

He wanted to make another point in relation to the grant situation. His

council had found that as they made progress as far as smoke control was concerned, they discovered that some people had already made conversions, but they did not qualify for grants because the area had not yet been declared. He believed that the Government ought to look at that, to encourage people, even before the area had been declared; if individuals wished to do something about smoke control, they should be allowed to do so and at the same time qualify for grant.

He had come to this rostrum to try and force the issue because he believed that delegates who were representatives of local authorities had a responsibility, under the terms of the Clean Air Acts, to implement smoke control programmes and it was time that they did this whole-heartedly. He himself had done so as had many other people but there were far too many local authorities who used inflation as an excuse, saying that there was not the money to do it; these authorities were kidding themselves, it could be done, it should be done and he hoped that when local authority delegates had left the conference they would convince their local authority, if they were not pushing ahead with smoke control, to do so.

Mr. N.J. Davis (Environmental Health Officer, Forest of Dean D.C.) wished to take issue with Mr. Biggs. He admitted to some notoriety in his home locality for taking issue with the planners regarding some of their decisions, and he did not think he was alone in that amongst environmental health officers. However, he was having difficulty in understanding the points put forward by Mr. Biggs and was wondering if in fact Mr. Biggs had studied the planning consultation arrangements which had existed since the reorganisation of local authorities; Mr. Biggs had talked about planning authorities in a rather broad spectrum. Mr. Davis asked whether he had been talking about the county authorities who were engaged in drafting structure plans, or had he been talking about district councils who had the responsibility for local plans, because they were very different, profoundly so. Mr. Davis believed he had also ignored completely the sins of the fathers, and that he ought to have accepted the position of existing users' rights.

Mr. Davis postulated a site on which a biscuit factory was located (which was an industrial use) and where it was the local joke when a rather unpleasant odour was emitted from the premises that "they had burnt another batch of biscuits", changing hands and becoming used by chemical manufacturers; the very different type of response from the local residents could be imagined if there happened to be emissions from those same premises, even though the emissions might be quite harmless.

It was certain, at that point in time, (he could speak only for his own local authority, but he suspected that it was the case in many many of the others), that there existed a very close liaison between the planning section of the authority and the environmental health department. Mr. Biggs had made great play of the work of the Alkali Inspectors and the role they should play. Mr. Davis asked that delegates should not be naive about that role; he would be the first to admit that technologically they were good, but they were numerically also very thin on the ground, and in fact in respect of processes in the industrial sense within the UK, they were responsible for a minimal number in relation to the total, and as the

gentleman from Newcastle had said most of the acute problems experienced in the industrial sphere were due, in his own experience, to poor management. He saluted Mr. Biggs' euphoric statement of "go to industry, they will be prepared", and he quoted further "to spend no end of expense in evolving environmental impact criteria". That was not his experience. He, and his department, experienced the greatest difficulty in extracting the kind of useful information needed for that type of study from the prospective purchaser of a site within his district. They were not prepared to spend a lot of money for that purpose on speculative sites.

In terms of planning consents, Mr. Davis thought that conditions to overcome a problem where a remedy lay within a major statute (he did not know from memory in which Planning Development Guidance Note this was stated, but it existed, and would not take very long to look up) could not in fact be used as part of a planning permission. He cast serious doubts on Mr. Biggs' philosophy that an ungoverned growth in the levels of wealth could be continued in terms of industry, because again in his personal experience, that philosophy had shown him that the advantaged became more advantaged and the disadvantaged became more disadvantaged.

Dr. R.A. Barnes (ESSO Research Centre) said that Mr. Biggs had referred in his paper to the recently published OECD report on the long distance transport of air pollutants. Before joining Esso two or three months earlier he had worked in the Central Environmental Policy Unit of the Department of the Environment - which was not the Clean Air Division so much criticised by other delegates! It had been his principal function in that Unit to co-ordinate the United Kingdom's input to the OECD report. He felt that the report was the most important environmental document published in 1977 if not in the whole decade.

Dr. Barnes referred to comments made the previous day by Professor Mellanby, who had pointed out that fresh water fish populations were declining in some parts of southern Scandinavia and that the decline had been attributed to the sulphur dioxide emissions from the industrial countries of Europe; the United Kingdom was often singled out as being particularly important.

To combat the situation the Norwegians were demanding that the sulphur dioxide emissions throughout industrialised Europe be reduced by at least 50%. Two independent estimates had put the cost of such a reduction at c. £1,000 million a year in the case of the UK alone. Yet the Conference had heard from Professor Mellanby - and he was not alone in his view - that the adversities on Norway could be more effectively treated by adding lime to the waters. Indeed, the Norwegians had costed such a course of action themselves at a mere £4 million a year and as Professor Mellanby had pointed out, such action had been used with considerable success on game rivers since before the turn of the century. However, the British Government was seriously considering the most cost effective means of reducing the U.K.'s emission of sulphur dioxide by 50% in line with Norwegians' demands although the much cheaper alternative of liming existed.

Dr. Barnes wished to ask Mr. Biggs, therefore, how the CBI would view an increase in power costs of around 25% which were not completely necessary.

Mr. H.K. Ghosh (Ministry of Works/Housing - Government of India) referred to Mr. Foskett's paper, in which he had outlined various measures adopted in the U.K. to control atmospheric pollution due to domestic smoke. Mr. Ghosh found the result in the U.K. really spectacular. He wished to point out the different aspect of the problem in various developed and underdeveloped countries in Asia and Africa, particularly in his own country of India. Due to climatic conditions in India, domestic smoke was merely due to the burning of low-grade smoke-emitting fuels, namely coal, cow dung, dry chaffs etc., by the poorer sections of the community in the course of their household affairs: not for room warming, since winter was not severe in most parts of the country. The majority of that population lived in shabbily built hutments in close proximity to the highly urbanised areas. Smoke emissions from these hutments caused the main problem in the urban areas of India. It appeared to him to be a very great problem which could not be tackled by passing legislation and equipping the local authorities with powers to declare some areas as smoke controlled zones, and taking punitive measures in case of violation. It appeared to be a socio-economic problem rather than a legal or technological one. Unless the social and economic conditions of urban areas were uplifted it would not be possible to control that problem in the developed or underdeveloped countries. Once an urban area was provided with proper housing facilities and a good environment with minimum basic amenities such as water supply and electricity, the menace of smoke nuisance would automatically be reduced. But that would be likely to take a considerable time as it was so much dependent on the resources of the nation. In the meanwhile he asked Mr. Foskett whether there was any cheaper and non-smoke-emitting fuel which could be supplied to the urban areas by the government, either free of cost or at very nominal price.

Mr. P. Draper (Individual Member) had been very interested to read Mr. Foskett's paper. He thought it an excellent exposition on all that Manchester had done in the past, and Manchester had really been a leader in clean air throughout, but he would have liked to have heard a little more from him of their future plans. Perhaps that would be possible at some other time.

With regard to Mr. Biggs' paper, which had referred to the 5th Royal Commission on anti-pollution and, in particular, to H.M.P.I., the subject which Sir Brian Flowers had raised at the 1976 Edinburgh Conference, Mr. Draper though that many delegates had been a bit upset to hear about this, (Her Majesty's Pollutant Inspectorate), as there was already a great respect for the way things were handled by the Public Health Inspectors and the Alkali Inspectorate. He suggested that the feeling was against some government body coming in and interfering with their work. But he did think there was quite a real need for another set-up which would provide specific information. This would be rather akin to a good library service, only a specialised one which would be of great help, both to the public health inspectors and to the alkali inspectorate itself; they were technic-cl people but even they could not know everything so he hoped H.M.P.I. would appear in some other form and probably by some other name.

Mr. R.P. Findlay (Deputy Director of Environmental Health - City of

Aberdeen) realised that some of what he had to say had already been said for him. Mr. Biggs had suggested that planning conditions should not be used to control pollution problems. He had to disagree with him. There were plenty of industrial processes that he was aware of which created pollution problems which were either not covered or were inadequately covered by any existing legislation or indeed by any of the government agencies to which Mr. Biggs had referred and, apart from the dubious expedient of the Public Health Acts, planning conditions sometimes seemed the only satisfactory way of trying to ensure that pollution problems from newly established processes were not created. Even if one could use any agency such as HM Pollution Inspectorate, in his case it was based 130 miles distant and complaints regarding dust from rock grinding plant, grit blasting etc. were invariably directed at the local authority. He appreciated Mr. Biggs' fear of duplication but a local authority did not satisfy its rate payers who were affected by dust from a grinding plant by referring them to some distant body more than 100 miles away. He was not knocking the Alkali Inspectorate, because his department had an excellent relationship with them, but he thought that there were certain areas in which planning conditions could act as an additional means of controlling pollution, without working at cross purposes with government agencies. He did not think that a planning authority was sensibly exercising its powers if it ignored possible pollution problems from new applicant industries. He said he would welcome Mr. Biggs' further comments.

Mr. A.I. Biggs replying to the discussion, thanked the Chairman for fitting in with his unusually limited time at the Conference. He also explained that since he had not prepared a written paper, he had tried to present one and high-light certain points. It was not the fashion he preferred. He would rather that a written paper had been available so that he could have picked on parts he wished to emphasise. One or two messages might not have got through very clearly.

In the paper, he had been commenting on the Royal Commission's comments on planning and pollution control; not on existing planning legislation. Any confusion that might have arisen about district plans and structure plans had been due possibly to the way he had picked it up. The members of the Royal Commission were not necessarily experts in planning, although they were quite well informed on the inter-relationship between planning and pollution.

On Mr. Cresswell's question about zoning, he said that industry would have preferred buffer zones but he agreed entirely that that did not mean that emissions should not be reduced as much as possible and that the principle of best practicable means should not apply. The C.B.I's main point was that it did not make sense to permit residential accommodation to come too close to either unpleasant and, in some cases, possibly dangerous industrial sites.

Replying to Mr. Holmes' question about the advisability of releasing information, he stressed caution as the word he would use in giving advice to any company, or indeed any local authority. He was quite convinced however that the most alert and knowledgeable local authorities would,

themselves, be cautious. He thought information should be made available but it should be meaningful. He did not disagree that there were certain pressure groups that would like to misuse such information; equally he agreed that there were many people who ought to have any relevant information and would not abuse it. Turning to Mr.Davis, he said he had answered some of his points by saying he had been merely commenting on the Royal Commission comments on planning and pollution. Regarding industry and growth, this was a philosophical argument but he thought the words he had used had been to maintain and improve our standard of living! If that involved growth, that was a necessary consequence. If change was needed to meet new technologies or developments, again, this was inevitable. But he was sure that very few people would willingly reduce their standard of living if they could have progress and also protect the environment. An Eskimo lived quite comfortably in the polar regions; a Mancunian lived well in Manchester. But transpose them and both would be extremley uncomfortable. It was a matter of choice.

On the need to spend £1,000m on SO2 and particulate reduction in the UK, he said that this argument had still to be resolved. Much of the imformation appeared to indicate that some of OECD's figures ought to be looked at in greater detail. But the first question could well be: what was the benefit which would derive? If the benefit was great what was the most expeditious way of achieving it? There were a number of options but one option, development of nuclear power in place of fossil fuels, might bring with it its own peculiar problems. He did not think there was a simple answer.

Replying to Mr.Draper he explained that the CBI had taken great pains in their response to the Royal Commission to say that the functions of HMPI should not overlap or erode the functions of existing authorities, particularly the Water Authorities, County Councils as Waste Disposal Authorities, and Local Authorities.

Finally, on Mr.Findlay's point about planning versus pollution, he did not believe they were separate; one became part of the other. Planning was the job of the planners, but he thought that when water pollution control was being considered or the disposal of solid waste or air pollution, other competent authorities were involved. The planners ought to consult those other authorities rather than make provision for pollution abatement in the planning permission. That would, in effect, lead to duplication and uncertainty. Consultation, once again, was, he believed, the key issue.

Cllr. Mrs.E.J.Inglefield (High Peak B.C.)
wished to endorse the remarks made by Mr.Holmes. She was herself an elected member of the authority of which Mr.Holmes was an officer. She spoke about the Borough's compliance with regulations 79-83 of the Control of Pollution Act. They had set up an industrial liaison group with representation from local industry, elected representatives, Health and Planning Staff and the Alkali Inspector. Already they were under great pressure to allow membership by members of the public and from vociferous fringe groups and civic societies. Naturally, the industrial members of such committees relied on the confidential nature of the content of the meetings and indeed would not participate if not assured of confidentiality. They had had one meeting

between industry, the local authority and invited members of local pressure groups and had found that the members of the action group had invited the press to be present. The reporter had been asked to leave but in spite of that a verbatim report appeared in the local paper the following day for which the firm concerned had blamed the local authority, and which had destroyed a great deal of mutual trust that had existed beforehand. The elected representatives naturally had been there to represent the interest of the public at large. She asked how the speakers viewed the prospects of successful implementation of sections 79–83 of the Act without destroying the often delicate balance of co-operation and liaison between industry, E.H.O.'s, and the Alkali Inspectorate.

Dr.A.Parker (Vice-President) realised that much had been achieved in the reduction of smoke emissions in Great Britain. Coal miners had been offered solid smokeless fuel but because the amount offered was somewhat less than the amount of concessionary coal to which thay had been accustomed, most of the miners had refused the offer. They did not seem to realise that the amount of smokeless fuel offered would provide more useful heat in the home than could be obtained from the larger amount of coal.

Mr.G.R.Millington (Wakefield M.D.C.) shared Mr.Foskett's disappointment regarding Circular 54/76 prohibiting the replacement of improved open fires, and felt that in the interests of efficiency a better class of appliance capable of burning all types of solid smokeless fuel should be permitted as previously. He urged that consideration be given to the re-establishment of "black areas" based on up to date information, together with compulsory smoke control programmes so that the task of smoke control could be expeditiously completed within those areas. Referring to planning consents he advocated that consents, once given, should not be valid for all time but should be subjected to an environmental review at regular intervals. Mr.Millington asked Mr.Foskett if he would use his influence to ensure that the question of smoke control received the attention it deserved from the Association of Metropolitan Authorities and the Department of the Environment.

Mr.T.R.Jones (L.B. of Tower Hamlets) asked Mr.Foskett, with regard to his reference to the sulpher content of fuel, whether he would necessarily reject or advise against the use of a heavy 3,500 second fuel oil as opposed to a gas oil in a district heating scheme, on those grounds, bearing in mind the small difference in sulpher content between the two and the cost of the fuels.

Mr.H.Giblin (Solid Smokeless Fuels Federation) wanted to refer to the points raised in Mr.Foskett's paper about the Department of the Environment's Circular 54/76. Mr.Foskett had suggested that the Circular doubtless had been intended to conserve finance but had paid scant regard to the urgent need of fuel conservation. Mr.Giblin disagreed with this view. He explained that in a smoke control area grants were often given to replace an approved open fire but unfortunately in the majority of cases these were open fires with back boilers. The efficiency figures for that type of appliance were higher than those quoted in Mr.Foskett's paper which were for the simple open fires. The approved open fire with back boiler had an efficiency of up to 50% and yet the DoE were prepared to block that off and give a grant to fit two

appliances, a space heater and a water heater, whose total thermal efficiency could be less than the appliance that was being replaced. Consequently from the point of thermal efficiency it could be a gain rather than a loss not to give people a grant to replace approved open fires. If thermal efficiency was the only yardstick it could be agreed that a grant should not be given on appliances that were less efficient than the appliances they replaced.

Mr. E.W. Foskett, replying to the discussion, said that many people had made contributions and he would try to deal as quickly as possible with the various points that had been raised. He though Mr. Cresswell had been quite right. He had not, himself, expected that no one would disagree with the things he had put in his paper. They had been in fact intended to stimulate the discussion, and if they had succeeded in so doing, he thought it so much the better. Many of the points that Mr. Cresswell had raised were such that the only shade of difference between them was perhaps one of emphasis rather than a matter of opinion. He accepted entirely the point Mr. Cresswell had made that one could not be critical of both local government and central government at the same time. He thought that was asking for too much. His hat was, he believed, very firmly on the local government for pollution control and basically the criticism that he had hoped to bring out in his paper had been to say no more than that there were lagging local authorities and that the central government had not urged them on sufficiently. He thought smoke control was a duty which local authorities ought to do and get down to. As far as public expectation was concerned, he though there was every evidence that this was the case. Perhaps the public was not altogether concerned with smoke pollution but certainly with other forms of pollution, particularly pollution by odours. There was no doubt about it in his mind that the public consciousness had been aroused. It could very will be, of course, that in some cases public expectation was being stifled by the fact that the people who held those expectations were not very good at making their wishes known or alternatively, their wishes were falling on deaf ears when it came to influencing the local authorities. Some of the questions that had been raised during the discussion really had been of most fundamental importance and would be difficult to answer adequately.

Turning to the contribution made by Mr. Holmes and Cllr. Mrs. Inglefield, it was a specific problem that they had and as they did not come from very far far afield from where he himself lived and worked, he was fully aware of the background to their problems, which were very difficult and perhaps ought to have been anticipated in highly populated urban areas with plenty of urban guerillas of that sort about, but would scarcely have been expected in the High Peak area. But there they were and they were causing a very great deal of difficulty, and the High Peak Council had certainly got a job on its hands in dealing with them.

It had been asked what the Greater Manchester Council for Clean Air did as far as the publication of information was concerned. They had done what all good local government bodies did when they were faced with that problem they had set up a sub-committee and the sub-committee had looked at the sort of advice they ought to give to the constituent members; that advice had simply been that, in the view of the Council, it was not possible for

that body to act collectively for the whole of the constituent authorities. Each authority had to deal with its own particular problems and if the need arose, they would have to develop liaison committees and do the best they could.

He thought that Mr. Holmes had a very strong point when he has talked about the difficulties which were likely to arise when insincere people or people who had a concealed motive acquired information and then did their best to use it for wrong ends. One of the things that had emerged was that the leg-islation had been intended to implement an idea. It had been intended to implement a facility which would be of value to people who were honest and who had a perfectly sensible objective in mind. But in many cases, it could be suspected that this would not be so. The sincerity would not be there, the information would be obtained for a dual purpose and would be used for blackening the local authority.

He concurred entirely with Mr. Holmes that the local residents were adequately represented by their local councillors. They had the remedy in their own hands, if they did not like the representation they had, they could change it at the next election, and they might get someone who would represent them from a basis of ignorance, not of knowledge of the problems, as the elected representatives had when they had been immersed in it for a period of time. Elected representatives had the benefit of the expert knowledge which was available for them or which could be obtained for them, and they made a sensible judgement on a wide number of factors and not simply on the issues that appeared to be superficially attractive. In many instances, when these issues arose, the only solution which would be completely acceptable to the people concerned would be to close the factory involved and when that proposition was put to them the issue shifted a little. Basically, complainants wanted the industry to go away, but they refused to explain how they proposed to find a livelihood for the people who were to be dispossessed. It was altogether a very difficult problem.

Mrs. Inglefield had asked how his Council would deal with that particular problem and he thought that the only reply he could make at that time was that it did require a very great deal of careful handling. He thought that there was a very great deal of responsibility on the shoulders of the Chairman. Most Liaison Committees had the solution to the chairman problem by electing two, one for each side, who sat at alternate meetings. That meant that the two Chairmen themselves had to have confidence in each other and, if they had such confidence and could lead properly, then there was a firm foundation for control at the meetings. Most companies, he believed, would take part in such meetings only on the understanding that there was adequate safeguarding of their confidentiality.

He doubted very much whether the Government would change the relevant legislation. He thought it demonstrated that the people who had drafted it had not had the slightest idea of how the liaison committees were to work. He did not think they had had the slightest experience of working in a situation where they themselves had to deal with members of the public. It was all very well in the corridors of power in Whitehall where they were insulated from the hoi polloi but local government officers and elected

representatives were not in that favourable position and they found themselves frequently in a situation of confrontation which was not of their own making, not of their seeking because they knew that out of confrontation there could only come conflagration and a conflagration was not usually a sound way of settling a difficulty. By experimentation, by keeping clear heads and keeping calm, he thought it might be possible for people to develop such committees, but he warned that no-one should be under any misapprehension that they had there and easy way of implementing the intentions of Parliament, because it was going to be a long, difficult road and he thought that when some more experience had been gained, people might be able to advise each other rather more appropriately.

Referring to Councillor Haynes' contributions, Mr. Foskett had found it refreshing to see him leather into everyone in the way he had done. He himself had tried to do precisely the same thing in perhaps a less robust way, but he had stated quite clearly on page 12 of his paper, that while the central government suggested constraints in the environmental sector, local authorities always had the power to proceed with smoke control if they had the will. It was that final phrase that gave the sting in the tail, it was the will to do it; the powers were there, the powers had always been there and it depended entirely on how the local authority ordered its own priorities as to whether it sought to do one scheme or another scheme or to take on board the completion of its smoke control programme. This could certainly be linked with the comments made by a later speaker who had wanted a further list of black areas and some certain exhortations to do better over a wider area.

As far as Mr. Ghosh was concerned, Mr. Foskett confessed that he had never been confronted with a more difficult question to answer than the one he had posed, and had to admit that he could offer really very little quidance; that came not from a lack of will to give Mr. Ghosh some guidance but simply from the lack of knowledge, as Mr. Foskett had minimal knowledge of the urban scene in India and the fuel resources there. The only point he felt he could made was to wonder whether, in the urban situation which Mr. Ghosh had described, perhaps domestic smoke control was the first priority that ought to be ordered. It might very well be that there were other things that were of even greater priority which if provided would make it easier to deal with the question of smoke control. As an example, one of the things that had been mentioned was the low standard of housing in India. Mr. Foskett thought it very likely that in the event of better housing being provided, better insulation of the premises and better means of burning what sort of fuel was available could be put in hand. But beyond saying that, he regretted that he could not proffer specific advice without knowing more of the situation.

Referring to Mr. Millington's comments, Mr. Foskett thought he should put him with Mr. Giblin in one room and allow them to answer each other's questions with regard to the replacement of open fires. He would himself be in Mr. Millington's corner and not in Mr. Giblin's in that particular case. There seemed to him no doubt that it was an economy measure in line with the other hints and indications that the government had been prepared to see smoke control cut back and it was not without interest that very

often the people who had suffered most in that particular field had in fact been council house tenants and not the ordinary citizens. He thought that was unfortunate. One of the most serious points about it had been brought out by a previous speaker. People could not understand why, in a new smoke control area, they could not have the same treatment as friends, neighbours and relations had had in previous ones. That was bad psychology, it was bad for the whole impact of smoke control and for the saving of, literally, a few score thousands of pounds per annum, it seemed an incredibly retrogressive step. What Mr. Giblin had said on another point was acceptable. It was about just that particular type of conversion about which there had seemed to be some doubt as to whether it had been an advisable thing to do at that particular time.

Returning to Mr. Millington's comments, he found it difficult to give any fast and hard undertakings about what could be said to the A.M.A., but certainly he had made a note of what Mr. Millington had in mind and he had no doubt that when a suitable opportunity arose he would be taking the point to the A.M.A. because, like Mr. Millington, he had feelings on the issue and when the appropriate opportunity arose he would be able to make an appropriate comment.

Mr. Jones had posed him the easiest question of the lot. He was going to make a sneaky answer to a question which had rated really a more serious one. If what Mr. Jones had suggested were to have happened in his own authority Mr. Foskett said that the issue would have been simple. The City Council had many years previously adopted a policy as far as its own installations had been concerned, that it would not approve any oil installation in its own premises which used oil having more than 1% sulphur content, and it had also resolved, and had carried it out, to try to secure that standard elsewhere. The Environmental Services Committee had always asked very pointed questions when they had been asked to approve an appliance which took a heavier grade of oil. Manchester did sometimes, in fact, in private installations, agree to 3,500 Seconds oil but those were circumstances where perhaps a new installation was being linked with one which was existing and economics did in fact crop up all along the line. But he explained that none of the installations would have been accepted until, at Managing Director level, the issue had been taken to them and, when the City Council itself had set the example and when the visiting officer could point to that example and to other people who had followed it, then the company which was involved had to think very seriously about whether they were going to go along with it or not. Very frequently the company concerned had to say that they were sorry, but they had considered using the lighter oil but would have to stand by their decision. If the subsequent emissions were to comply with the Clean Air Act then, of course, there would be nothing further that the City Council could do about it.

THE ENVIRONMENTAL PROGRAMME OF THE EEC AND ITS POSSIBLE EFFECTS ON EXISTING CLEAN AIR LEGISLATION

A.J. Fairclough
Central Unit on Environmental Pollution, Department of the Environment

Professor R.S. Scorer (Deputy Chairman, NSCA), opening the discussion, thought he had got the message. Mr. Fairclough had put it over as modestly as he had yet seen it done: it was that the U.K. was not doing too badly in educating the EEC in common sense. Britons could be thankful that the procedures invented by the EEC were time-consuming because it gave them time to learn. He admired enormously Mr. Fairclough's patience. Although Professor Scorer was himself a bit of a revolutionary and iconoclast, his book "Pollution in the Air - problems, policies, and priorities" was really an exposition of the British viewpoint evolved over a century of pollution control experience.

As he had come into the hall he had been approached, as many other delegates might have been, by some young enthusiasts who wanted to get rid of all lead from the environment. He felt that they were part of the same trend in the age as the EEC. They were starry-eyed idealists who had chosen an aim and imagined that by achieving it they would make an impression on the great issues of today; yet somehow or other their effort was misfiring. The previous day mention had been made of fringe environmentalist groups - the greatest of these was the EEC: it started with principles laid down in a vacuum. Like the youngsters who said " lead is poisonous, we mustget rid of it all regardless of the economic consequences", they had listed compounds which they had declared would be the subject of legislation and then had had to make all sorts of quite outageous assumptions in order to provide a base for their proposals. Lead was indeed on the EEC's list. So was carbon monoxide, and anyone might have thought on the basis of the commission's proposals that none of them had known anything of the great pioneer work on CO by Professor Haldane, so ably described by Professor Lawther (in Shell's magazine "Quality"), nor of anyone else's work for that matter. They had suggested that the air should be freed of CO to the point where no-one in the street would ever be found to have more than 0.3% CO saturated haemoglobin in their blood. Yet no-one in the conference hall had less than the quite natural level of 0.5%, including non-smokers.

Professor Scorer thought that when a prestigious body like the EEC, the pinnacle of the greatest technological and scientific culture ever, came up with such nonsense, it should be questioned. It was, he proposed, due to the starry eyed idealism which imagined that principles could be announced, once for all, to guide every member of society in the most efficient way of doing everything, and then sought to compel everyone to do it for their own benefit. He was glad that there were patient people like Mr.Fairclough who perseived that the education process had to take a long time.

He considered such idealism to be a product of the age. The style of education in physics had changed during the previous generation from concentrating on such basic matters as the conservation of matter and energy and the laws of nature which constrained people and which could not be

cheated, to belief in endless economic growth, nuclear technology, and unlimited computers which would enable people to control anything they might wish. People were to become the ideal shoppers for whom the waiting had been taken out of wanting. No-one had considered in any depth what such an attitude might do to people, and upon what the parasites that they would become would actually live. Fortunately that ideal was utterly unrealistic anyway so that people could not be nannied into being the ninnies it would wish them to be.

The assumptions on which the part of the EEC structure he was criticising were based had been generated during the 1950's and 60's when economic growth had become a dogma that it had been heresy to question. Professor Beckerman had said that because there had been economic growth for 2½ thousand years it would be possible for another 2½ thousand. On the basis of growth of an average 0.003 per cent for most of that time he had sought to justify 5 to 8% for the forseeable future, i.e. for ever for practical purposes.

Another assumption that had been made relevant to air pollution, was that there existed a dose-effect relationship for a pollutant and the consequences to health. It was almost as if such a relationship existed because it had been declared, and thus the intention was to find it; but everyone who had done any scientific research knew that the end product was not the same as the objective declared at the beginning. The true complexity of any relationship there might be was just beginning to be appreciated.

As Professor Lawther had frequently pointed out it was always possible to find someone so close to death's door that a passing motor cycle could cause them to pass through it. But that did not mean that all motor cycles had to be prevented from passing down all streets, although that appeared to be the kind of objective that the Commission had been setting themselves in relation to CO.

Professor Scorer asked whether it was necessary to legislate in order to protect all society's weaklings who might wish to venture anywhere that could be hazardous for them. Such a philosophy had unfortunately taken hold of many well meaning environmentalists, including some of the protection agencies in America, where one regulator had annouced at a 1976 conference Utah that he was seeking to ensure that nothing available in the shops could do any harm to anyone. It was no use saying of aspirins "don't take more than 3", it ought to be difficult to do so; people ought not to keep soluble aspirins in the house in case adults left them within reach of children who liked the taste of them.

The ideal person in the society that had been envisaged had been so nannied that he was a ninny, protected at every turn from his own possible folly. He was dressed in new clothes with his bankers card, spending his days shopping, in mechanised sport, in spectating upon life, with always another device to keep him out of mischief when he was bored. The culture thus envisaged was utterly frivolous and irresponsible, indulgent and degarding.

A war had been declared on waste! Yet when the UK had been about to enter

the EEC people like Shirley Williams had pointed to the increased consumption that could be expected. The war on waste was a war on the whole EEC concept. The International Monetary Fund was advocating that the rich countries should spend more, as a means to promote more sales by the poor countries. That incredible philosophy was a natural corrollary to the belief in economic growth so energetically taught in the 1950's and '60's, and it could not last.

Finally he wished to say a few words about fluorocarbons because the subject had been raised and Mr.Moorehouse was, unfortunately, not at the Conference to say what he had intended on the subject. The Clean Air Council had recently put out a statement which Professor Scorer hoped the Society would publish so that it could be considered at leisure. Briefly what the CAC had said was that insofar as there was any evidence, it was that amounts of ozone in the stratosphere had increased during the previous 50 years by around 5 or 10 per cent according to geographical location. That was probably a consequence (not a cause) of slow climatic change, but it was not known for certain. The CAC were not aware of any disadvantage having existed when the levels had been lower than in 1977. During the same period skin cancer had increased several fold. In some sections of the light skinned population of the U.S. the malignant form (which was rare there and very rare indeed in the UK) had increased twelvefold (1100 per cent!) since about 1939. The statistics for the non-malignant form were far less reliable.

It could not of course be deduced that the increase in ozone had caused the increase in the cancers, especially since the effect to be expected when the ozone absorbed MORE ultraviolet sunshine was that there would be LESS, not more, skin cancer.

All of man's activities which had been predicted to decrease the amount of ozone in the stratosphere had grown during the last 50 years - flying in the stratosphere, setting off nuclear explosions, increased use of fertilisers. There was thus no evidence that the predictions were correct.

What were the predictions? They were that if the use of fluorocarbons was continued at the 1973 rate the effect would be that the amount of ozone would decrease by 3 or 4 per cent in 50 years and by about 7 per cent in 100 years with no further decrease after that. That prediction was often referred to as "evidence". It was nothing of the sort. It was merely a theory which many people believed to contain serious errors, mainly because it supposed the atmospheric mechanisms to be much simpler than they were known to be.

The theory had attained some notoriety because it employed big computers and had produced a definite answer, which its critics had not done because they did not have such a simple view of reality and had not been able to model the atmosphere to their satisfaction largely because it was too complex and their available information of detail was so sparse.

Insofar, therefore, as there was any evidence on the matter of the relationship between fluorocarbons in the atmosphere, ozone, and skin cancers, it was that there were effects going on which had caused increases in the incidence of skin cancer many times greater than even the grossly simplified

theories predicted from fluorocarbons. These effects had been described by the U.S. National Academy of Science report of September 1976 as cultural. They appeared to arise from the habit people had developed in recent years of excessive exposure of the skin to sunshine to which it was not accustomed.

The Clean Air Council had taken the position that there was no need for urgent action. The Meteorological Office calculations could find no climate effect from an artificial reduction in the amount of ozone, and in order to make more definite statements it was necessary to wait for extensive measurements in the stratosphere over several years. There was certainly no justification for restrictive legislation at that time, and he proposed that if anyone was really worried about skin cancer they ought to be urgently occupied with seeking to remove the known causes of the known very large recent increase. Actually nothing was being done by the protection agencies in that direction and one could not take seriously their worries about the relatively innocuous, and entirely theeoretical, effect of fluorocarbons.

He considered it important to back up those who took a moderate, sensible view of the role of restrictions in society. It was bad government to multiply prohibitions, and all such moves ought to be subject to prolonged and searching scrutiny. In conclusion he thought that Mr.Fairclough should be given every encouragement in the sensible approach he was taking, and Professor Scorer wished him well in his efforts.

Mr.P.Draper (Indivisual Member.) regretted that he could not speak in the picturesque terms of Professor Scorer, but he did have a few comments he wished to offer. He thought Mr. Fairclough's was a most enlightening paper; it indicated the vast amount of work, not only to standardise the international approach, but more to show the near impossibility of doing so. It was most helpful to have the brief descriptions of the Commission and the Council. The former with a staff of 7 to 8,000 people were supposed to ensure the proper functions of the Common Market while the latter legislated. Who the Council ministers were was not clear to Mr. Draper and he asked if the author could enlighten him on that point. But it had been stated that the Council's duties were to offer non-mandatory opinions on the Commission's proposals. What an enormous advisory forum! Thus it would appear to the uninvolved as a monstrous and unwieldy means of arriving at decisions which no member country needed to adopt. Mr. Draper considered that thanks were due to the Central Unit on Environmental Pollution, of the Department of the Environment, for sponsoring the views so well expressed in the paper. The attitude expressed in the second half of the paper was, he felt, very sound and appreciative of the clean air efforts of the United Kingdom during the past quarter century; a great deal of useful work really had been achieved.

Making more detailed comments Mr. Draper said that paragraph 42 of the paper had indicated that the European Commission seemed to be giving priority to water pollution. He suggested that it was basically sound and considered that the same priority could be accepted in the U.K. Referring to paragraph 44, he thought that waste of effort being devoted to sulphur dioxide pollution was to be deplored. He agreed with Professor Mellanby's findings on

the subject. In addition there would be a costly waste of fuel resources if the sulphur contents were to be restricted. That statement might need amplification to some people but he hadn't time to do so. Turning to paragraph 45, he remarked that much effort and discussions were being wasted on the subject of lead, particularly on that in use as a beneficial additive in petrol. The author had said that the scientific basis of lead effects was not strong, which was a diplomatic way of saying that no danger was foreseen from lead in petrol. The modulating of more dangerous emissions was of course essential. In paragraph 49, the author had mentioned a few priorities other than air pollution which were receiving the attention of the EEC. Mr. Draper suggested that this list should be a guide for effort during the next decade or so, as long perhaps as it was not increased to include every element in the periodic table; because these could all be pollutants, oxygen could be one of the worst, and could be the one impossible for people to do without, etc. Finally, he wanted to stress the urgent need for the Central Unit of Environmental Pollution, as well as several other amenity efforts, to be transferred to a Department <u>for</u> the Environment. That would imply that the benefits achieved would be for the improvement of the environment rather than for the exploitation of it. This was not an original thought, although he had held this belief himself for a very long time, but it had also been stressed on more than one occasion by the NSCA's President, Sir Brian Flowers. It was a thing that had to be sought for the sake of the whole nation.

<u>Mr. B. Lees</u> (Individual Member) said that many years ago Professor Scorer had drawn attention to the importance of low level emitters as a major source of localised pollution. Since those days, many conditions had improved. Domestic heating emissions had been reduced as a result of the Clean Air Acts. Chimney heights had been raised but where there were many chimneys, as in towns like Harrogate and cities like Manchester, Leeds and London, raising the height was not always effective in reducing pollution. It might reduce local pollution but the pollution was only spread over the city.

So far the UK had concentrated mainly on smoke (particles below 5 microns). It was time to think about the next step, which was reduction in emission of particles of above 5 microns in the range of 5 to 100 microns. The quantity of unburnt solids emitted from oil-fired plant had been reduced by minimising the emission of smoke but not dust particulates. The Environment Action Programme, referred to earlier by Mr. Fairclough, had asked for facts and Mr. Lees proposed to indicate what he thought should be done to reduce those particulates.

UK legislation was far less stringent than the legislation in corresponding European countries with regard to emission of dust and grits. For example, with small oil-fired plant such as package boilers and small water tube boilers, UK law was satisfied when not more than 4 grammes of unburnt solids was emitted per kilogramme of fuel. On the continent they went down to much lower levels of the order of 1½ grammes per kilogramme of fuel. He wanted to ask why Britons should be satisfied with dirtier cities in areas like Manchester, Leeds, Harrogate, London, than in corresponding areas in Europe and in America. It could be said that the U.K. adoped the "best

practicable means". In the Autumn 1977 "Clean Air" it had been shown that oil-fired plant fitted with cyclones could operate with an emission well within the most stringent European standards. Using that development British boilers and other British oil-fired plant could be operated within the stricter European standards. In the interests of clean air, he suggested that Mr. Fairclough sould support the Europeans in introducing standards which were stricter than those in the UK but which could be achieved by "practicable means". To be specific, support should be given for an emission of not mor the 1.5 grammes of unburnt solids per kilogramme of fuel for oil-fired boilers and other oil-fired plant.

Mr. E. Hughes (Rolls-Royce Limited) explained that he was not a member of the NSCA, and supposed that he could be told that he was a polluter. He was naturally interested in legislation related to gas turbines and was very interested in legislation affecting emissions of oxides of nitrogen, carbon monoxide and oxides of sulphur. His company operated in a world market and therefore had to be sensitive to all legislation, especially UK and European legislation, although Rolls Royce's greatest market was in the USA. Having recently been involved in US legislation and the problems thereof, he was naturally extremely pleased to see that the UK was holding tight to the best practicable means but he proposed that the methods adopted by the Americans,who set standards that most certainly made industry jump, could be useful in the UK: in other words, not to look towards the horizon, but to look today at a possible tomorrow.

Questioning Mr. Fairclough, Mr. Hughes spoke first very much with tongue in cheek when he suggested that the proving of toxicity and the establishment of standards was relatively cheap, but it was in the achievement of those standards by industry where the money was rally needed. In the USA standards were set, many of which were unrealistic and had come to grief. Not long before, the US motor car industry had been required to comply with legislation which suggested a figure of .02 grammes per mile on the oxides of nitrogen: subsequently, the American motor industry has told the Government that they would not be able to produce their 1979 models because they could not meet that requirement. Therefore, there had been a 1977 amendment to the 1970 American Clean Air Act, which had effectively said that until 1981 cars could emit .2 grammes per mile, and beyond that date they could emit .1 gramme per mile. In other words, the original legislation had been proved to be very unrealistic.

Returning to his main point, he asked Mr. Fairclough how serious was the European Common Market and how serious was the Department of the Environment with regard to air pollution. He knew it had been set as a low priority in the EEC's Environment Action Programme. He wondered whether they intended to take the American approach and say that certain standards had been determined, and they would fund industry to meet those standards. What had to be realised with firms like Rolls-Royce was that they had to market in America; American industry, via their Environmental Protection Agency and the Energy and Research Development Association, poured multi-million dollars into supporting Rolls-Royce's competitors to produce low pollution gas turbines for them,so that became akin to a technical tariff barrier. He therefore asked whether the EEC intended to fund the European

motor industry in a similar way. Making another point with reference to US practice, he said that there, proposals were put forward on to the Federal Register, 60 days were then allowed industry to respond, and thereafter it took possibly a year of negotiation before a proposal was promulgated. He asked whether British industry would have the same facility with the EEC.

Dr. A. Parker (Vice President) said that the EEC had a large and costly staff and the principal members of the staff generally had little or no scientific and technical knowledge or industrial experience. They could consult members of the staff with scientific knowledge, but did they really properly understand what the scientists told them. So far in general the EEC had not reached any useful conclusions on questions of the environment. The cost of the EEC must be very great. He asked whether Mr. Fairclough could say what was the annual cost of the EEC?

Mr. E.B. Briggs (BP Oil Ltd.) referred to the need for wider consultation before the Commission submitted a proposed environmental directive to the Council. That might preclude naive or unrealistic requirements such as had appeared in earlier proposed environmental directives. He also emphasised that the Member States' manner of applying the detail of an environmental Directive would vary and suggested that this should be considered in any discussions and negotiations.

Mr. C.T. Savin (BP Trading Ltd.) thought there was a bond of sympathy between speakers that morning, since he believed that Mr. Fairclough had struck a well of worry about the EEC legislative processes. There was an apparent lack of recognition of local initiatives and local competence by the Brussels bureaucracy and it had been re-assuring to hear of the UK opposition to attempts to impose uniformity without ascertaining whether there was a need for that. He thought that one problem was that once a draft directive had been tabled with the Commission only two possibilities seemed to be open. One was to amend the draft as it stood, the other was to reject it outright. It did not seem possible to withdraw it and get the Commission to think again. He wondered whether Mr. Fairclough believed that the procedure could be modified.

The other point he wished to raise was whether Mr. Fairclough believed that the formative processes and the preliminary discussions by which the Commission prepared a draft could be made more open to knowledgeable people. It was understood that the integrity of the Commission had to be respected, but at that time it did appear that they often ignored the wide range of talent and information which was available within the Community. The preliminary draft of the charging system for water effluents was an example of the approach that caused people concern and worry.

Mr. C.R. Cresswell (Principal Environmental Health Officer, Newcastle upon Tyne) expressed concern about the enforcement of standards. He had been fortunate enough to have the opportunity to study the German and Italian methods of enforcement and in these countries it left a great deal to be desired. Should there be an international inspectorate to ensure that all community members complied with standards? That seemed impracticable and

unacceptable. What happened when it became apparent that one country or another was failing to comply? Would the offending country be asked to resign from the community? He thought this unlikely. Would pressure be brought to bear on backsliders in more subtle ways? These questions appeared to him to be vital. Standards and legislation without enforement were pointless. He said he would be interested to hear Mr. Fairclough's views.

Mr. R.W. Wakeley (Commonwealth Smelting Ltd.) wished to congratulate Mr. Fairclough on a very comprehensive paper which had cleared a lot of confusion in people's minds, but he was a little bit worried about the intensity of the "We and They" sort of feeling that was coming through the argument, not only at the Conference but elsewhere. It was reminisent of the past feelings that all unpleasant people commenced at the English Channel.

Comments had been made on questions of "educating the EEC in common sense". First of all, as he understood it, consultation by expert groups which took place fairly early in the process included UK experts, so what was going wrong there? Secondly, he thought that Mr. Briggs had dealt with an argument on the same lines. It was being said that by leaning fairly heavily on the environmental quality objectives approach, UK experts let themselves in for an awful lot of hard work in proving their case. They were going to do a lot of expensive monitoring to prove that they had got the right method of approach. Also, had standards been set, they as good boys would, of course, always make sure they got it right but, once again, nobody else across the Channel would do so. He felt that kind of argument to be a little bit excessive.

The other point he wished to make concerned trans-frontier pollution by SO_2. He thought the Trail smelter in British Columbia had been one of the earliest cases of this. Here, SO_2 from the smelter had been passing across from the Canadian side to the American side, a distance of about 14 miles or so, and damaging pine trees. The way that had been overcome, after legal battles, had been by setting a kind of standard for SO_2 which had meant that the smelter had been cut back in emissions. Since those times he doubted that there had been any trouble from the point of view of damage to trees or any other polluting effect of consequence. So that was a much smaller scale than the trans-frantier pollution now being discussed continentally. But, at the same time, he did not wish to give the impression that he was arguing for fixed standards; he was certainly not in favour of rigid numbers.

Mr. A.J. Fairclough, replying to the Discussion, said that there had been quite a range of points to deal with, and that he would do his best.

He wished to make a couple of comments on what Professor Scorer had said. He thought that his question, "Do we have to legislate to keep the weakest members of society alive" - although that was not exactly how he had put it, - was a fair one. In a sense it was one that many members of society had to face up to - doctors for example; but he thought that there was another side to it. Certainly in the field of environmental protection it was very

arguable that a humane approach was necessary and involved taking a fairly careful look at the most susceptible groups in society. The 'critical group' approach was one that had been very directly applied - in relation to radioactivity for example. It also had to be recognised that politically and morally it was difficult to defend a situation in which attempts were not made to protect those who could be called the weakest. By that, he did not mean that he was necessarily arguing against Professor Scorer's assertion that much of the modern way of life had generated weaklings, but he was talking about how the population that existed could be dealt with. If a generation of stronger men was to be created, that was for the following generation to do; meanwhile, he wondered how existing problems ought to be faced. He wished to suggest simply that there was a need for a humane approach; that implied care for those who were particularly susceptible. Precisely what that meant in detail was, of course, difficult (as things always were) to work out in practice.

He had been extremely interested in what Professor Scorer had had to say on chlorofluorocarbons. He regretted that he had not (even though the Central Unit was in charge of co-ordination within government on stratospheric pollution) yet seen the statement to which Professor Scorer had referred, but he would look at it later with very considerable interest. Within government for their part the Department of the Environment had also taken a somewhat cautious approach (as he had tried to indicate) to the whole matter; and they were resisting American attempts to bounce the world into immediate regulatory action. Whether or not in the end regulation would be desirable and undertaken remained to be seen; but certainly there were, as Professor Scorer outlined, many uncertainties indeed in that whole area.

Mr. Draper had asked who the Council Ministers were. Mr. Fairclough regretted it if his paper and exposition had not made that plain; on reflection it was clear that he had not gone into quite enough detail. He explained that the Council consisted of one Minister from each member country. If they were discussing agricultural subjects it would be the Ministers of Agriculture sitting as the Council. The indivisable Council of the Community could comprise different individuals. If foreign affairs were being discussed, it was the Council of Ministers comprising, in that case, the 9 Foreign Ministers; if it was environment that was being discussed, it was the Council of Ministers comprising the 9 Environment Ministers; and so on. He stressed that there was no sense in which the Council's decisions were non-mandatory. They were mandatory. They were the actual decisions of the Community. The non-mandatory opinion to which he had referred was by the European Parliament. The European Parliament (in which members of all the national Parliaments sat) was invited to give an opinion on proposals that went from the Commission to the Council. The Council of course took those opinions into account in reaching its decisions. But the decisions were the Council's, and member countries were bound by them. The unanimity rule meant that all member countries consented to a decision in the Council and they were then obliged to implement it, whatever it was. If the decision was one which simply laid down guidelines then they had to attend to the guidelines; but if it laid down, in the air pollution field, mandatory levels then action had to be taken to meet those levels. Whatever form a decision of the Council took - whether it was to adopt a

recommendation or directive or whatever it might be - the conclusion of the debate was binding upon member countries.

Mr. Draper had also pleaded for a department for the environment. The environment for the individual man (as his Minister of State, Mr. Howell, had once put it at an OECD meeting) was what happened at the end of his road; and the nature of the road, the nature of the houses in it, the green spaces that were near by, the services and facilities that were available, were all part of the quality of life and therefore of the environment. So he thought that one should not really consider the environment narrowly as meaning protection from pollution. In the sense of the wider interests of DOE for relations with local government, for land use planning, for housing as well as for countryside policies, nature conservation and pollution control, they liked to think that they were already a department for the environment. It was an argument, an urging, that Sir Brian Flowers had put forward on many occasions; and Mr. Fairclough had been reading only the previous night in his room, 'Clean Air' for Autumn 1977 in which the point had been again repeated - in reporting Sir Brian's Presidential Address, July 1977. It was a fair point; but he thought that the DOE would argue that they already (to some extent at least) filled the bill.

Mr. Lees had asked why the UK should be satisfied with dirtier cities than Europe or America. And he had made a specific numerical suggestion to Mr. Fairclough for which he was grateful and which he would take back to the Department. In a sense that was the sort of issue that he had already aired: he wondered whether it was a local matter, or whether it was a matter on which the Community should act. There was nothing to stop the UK deciding to have cleaner cities than anywhere else in the world; that was a matter upon which the UK could act for itself. In particular cases it might be desirable to argue that there were indeed national matters for national decision within the whole range of priorities under discussion; in other cases it might be desirable to accept that Community-wide action was necessary.

Mr. Hughes had asked how serious people in the UK and in the Community were about pollution: if standards were set, would the government fund action. The answer to that, he thought, was an emphatic "No". There was a clear committment by the Community and by all OECD member countries to what was called the "polluter pays principle", which, put simply, was that the cost of abating pollution to whatever level a particular society decided was desirable or necessary, was a proper cost of production for the product concerned and should be borne by the product; and that only in that way was the actual price to the consumer of the product an adequate reflection of its total social and production costs. That was not to say that public money did not go into, for example, research on methods of pollution control which might in fact be beneficial to particular companies and so forth. But the actual costs imposed upon industry, at the end of the day, were costs which the DOE would certainly argue strongly should be borne by the industry and the products which were generating the pollution.

Mr. Hughes had appeared at one point to be rather in favour of stringent, tough, numerical standards which would make industry jump. Mr. Fairclough

pointed out that the experience of Japan in that context was extremely interesting. They had done precisely that (having previously done nothing for a long time). In about 1970 they had decided on very tough controls and their macro-economic indicators since then had suggested (although they were by no means precise), that there had been virtually zero effect overall. Obviously there had been effects on particular companies; but one consequence of Japan's sudden imposition of very tough standards had been to generate a large new and successful pollution control industry which had offset the costs in other parts of the economy. He deduced nothing from that. It might be a very special case. But he thought it was interesting.

Dr. Parker had asked a very fair question to which Mr. Fairclough regretted that he simply did not know the answer. He asked how much had all their deliberations cost the EEC. That was plainly the sort of question to which there was no easy answer. He supposed however that it was true that there was a considerable committment of personnel in discussion and negotiation continuously; and not only in the environmental field. That had been recognised when the UK had decided to join the Community; that was part of the Community's procedures and processes; that was the way it set about its business. But he could not answer the more general question.

Mr. Briggs had been disappointed at the nature of Commision proposals at the point where they became public and had asked whether there could be more consultation before then. And Mr. Savin had also asked whether the preparatory stages could be made more open. He thought that he scarcely needed to say after his talk that they were preaching to the converted. What he meant was that the DOE were in favour of better preparation so that what emerged from the Commission to the Council was not inadequate in any obvious sense. It might be something that one disagreed with; but it should at least be soundly based. He believed that so far as the UK was concerned (and he though that applied to other member countries too) there was very close consultation between the government officials involved and the experts involved and industry. In principle the DOE welcomed that very much and he thought probably that Mr. Savin and many others at the conference would know that officers of DOE and of other Departments concerned were in close touch with industry about these things at the stage when proposals were being prepared. Whether it could be more open or the consultation within particular member countries could be better, was a fair point - and he thought that whatever could be done to improve matters should be done. It was a point that could be made to the Commission, direct by anyone who was in touch with them; and of course they were accessible in the sense that they saw a lot of people who went to see them.

Mr. Cresswell had questioned enforcement performance. He thought it a natural doubt to express. His own view (which he did not claim was authoritive in any sense) was rather more on the lines of what Mr. Wakeley had said, which was that it was too easy a view to take. He doubted whether enforcement was as bad as people liked to thing; and thought that there was perhaps a tendency for people in the UK to pat themselves on the back and say how well they did and how badly everybody else did. The evidence that was available suggested that that was not as true as people

in CUEP or in Government has been used to think; and the whole question of enforcement and the role of the Commission (and of course it could be in part a Commission role in keeping in touch with implementation measures and follow up measures) was something that was really for the future, in the sense that very little in the way of environmental protection measures had yet been firmly adopted and implemented. But it was an important question; and it was one that the DOE were conscious of and had in mind.

Finally, turning to Mr. Wakeley's remark about the "we and they" feeling, Mr. Fairclough said he had also been a little bit bothered about that. What he had tried to stress in his talk was that a process of interaction, a process of negotiation,was implicit in action at EEC level. Certainly there were differences of approach; certainly there had been some arguments; but there were already signs of growing recognition of one another's points of view. And the fact of the matter was that, in order to achieve any results, an arrival at unamimity was necessary. So he very much shared Mr. Wakelely's view that the UK should not be too isolationist in that respect. Certainly the UK should argue its corner; certainly the UK should express its particular point of view; but as he had said at the end of his talk, the hope was that eventually the mutual understanding would have gone far enough so that what emerged from negotiation in Brussels would not be all that different from that which people in the UK might have thought up for themselves.

AIR POLLUTION AND PLANTS
P.J.W. Saunders
Natural Environmental Research Council, London

THE INFLUENCE OF AERIAL POLLUTION ON AGRICULTURAL CROPS
Professor C.P. Whittingham
Rothamsted Experimental Station

EFFECTS OF ATMOSPHERIC POLLUTANTS ON FORESTS AND NATURAL PLANT ASSEMBLAGES
Professor F.T. Last
NERC, Institute of Terrestrial Ecology

Mr. P. Mitchell (N.S.C.A.) started the discussion by remarking that it was the first occasion on which the subject of the effects of air pollution on crops had been extensively dealt with during a Clean Air conference. He wished to congratulate the three eminent authors for their comprehensive coverage and detailed references. He agreed with Dr. Last's comment that there was an enormous amount of information about the effects of high concentrations of single gaseous pollutants on a few young plants. The results of such experiments were rather suspect when one tried to relate them to experiments carried out in the field where many different species of plants and pollutants existed. Dr. Saunders had suggested that the effects of air pollution on crops, in its broadest sense, cost each man, woman and child about £8 per head per year. If, for example, it cost £10 per head to clean the air, everyone was out of pocket by £2. To the economists that would be incorrect but the conservationists would say that it was money well spent. However, what was more pertinent, in days of a high cost of living, were the costs suffered by the allotment holder: for example, the effects of pollution from a domestic oil fired boiler on a row of cabbages in winter. This was very hypothetical, of course, but he would welcome comments from the panel on such a case. He himself had greenhouses and frames and the greasy substance resulting from low level emissions was very noticeable on the glass and doubtless it was on the plants outside.

Commenting that motorways tended to be routed through agricultural land, Mr. Mitchell thought that the pollution resulting from the traffic ought to have some effects on the crops but he had gathered from the three papers that very little was known. One logical step was to only sow the embankments with the seeds of grasses that were partially susceptible to air pollution from motor vehicles, thus saving the costs of grass cutting. Finally, on possibly a more futuristic note, he asked what, if any, were the possible effects on vegetation of pollution from the production of nuclear power.

Professor F.T. Last responded to Mr. Mitchell's remark about grass on motorway verges. That interested him greatly: as a result of recent continuing programmes of salting in winter time, some sand dune grasses had begun to colonize the verges of major UK motorways. Professor Last wondered whether it was appropriate, if salting programmes became routine parts of motorway management, to reconsider the types of grasses to be sown. He thought that there was a lot of good sense in that.

He wished to extend the argument a little bit further. His colleagues had indicated during their talks that plants growing in urban situations were more damaged by pollutants than plants elsewhere. If that was so, was is not appropriate, he wondered, for urban plants to be selected from stocks successfully growing in urban areas? Nurserymen ought to derive their stocks from trees that had actually grown in polluted areas. There were many possible examples e.g. London plane. He believed that nurserymen should propagate from trees with proven performance in polluted conditions rather than use specimens developed in non-polluted areas when considering appropriate planting stock for towns.

He left the question about glass houses to his other colleagues, after indicating that smoke was in that instance likely to be a major damaging component of 'pollution' - dirty glass restricted light transmission. The cost of cleaning glass had been not long before a major cost in glasshouse maintenance. There is little point expensively maintaining temperature, humidity, amounts of carbon dioxide if the light intensity was inadequate.

Professor Whittingham said there was now little doubt that in winter the effect of aerial pollutants on the growth of vegetable crops was greater than in summer and probably in almost all cases aerial pollutants resulted in decreased growth. Under other growing conditions it was conceivable that certain pollutants could produce increased growth and it was unwise to generalise concerning the effect on all crops under all growing conditions. From a national point of view it was important to consider what proportion of total vegetable production arose from allotments in or near urban areas and the overall production in market gardens. Even if only a small loss arose in market gardens, because the acreages were so large, the national loss could still be significant.

The possibility of adaption was unlikely to be significant in the case of arable crops or vegetables which grew only for one year. There was, however, the possibility of selecting varieties which had a lower sensitivity towards specific pollutants. It was of course necessary to ensure that the selection of resistance was not accompanied by a lower productivity. Laboratory experiments had indicated some possibility of selecting a high-yielding strain of barley, which was much less sensitive to the effects of sulpher dioxide. However, at the present time a whole variety of other factors which influenced the yield to be considered as of equal importance with the requirement of tolerance to aerial pollutants.

Dr.P.J.W.Saunders, replying to Mr.Mitchell's query about motor vehicles thought it depended very much on how the problem was studied. A whole series of different pollutants had to be coped with. There was a considerable amount of work being done, for instance, on photo-oxidants, in terms of general pollution in the UK not specifically related to motorways. Professor Last had touched on the issue of road salt, one that really was countered by a different approach in which one looked at the establishment and maintenance problems of motorway vegetation and so on. He thought the Department of the Environment had played a role in trying to sponser some research in that direction. But there were a number of other pollutants that were rather interesting for different reasons. For

instance there had been some work done on lead emissions. Primarily it had been on the effects on plants, the main issues being where the lead goes to and whether it went into UK agricultural crops, wildlife and water supplies. Generally, it did not seem that it would have, at least in the foreseeable future, a significant effect upon normal vegetation in the vicinity of motorways. Turning to nuclear power activities, briefly, he believed that the experience there rested very much on work carried out shortly after the war in the UK and abroad, particularly in the USA, where virtually all plant life had been found to be so much more tolerant of radiation than were animals and human beings; he thought it really would not be a worthwhile exercise to look at the direct effects upon plant life as such. The re-colonisation of some of the atom and hydrogen bomb test sites in the Pacific had shown that radioactivity had very little long term effects on the vegetation. The animal life was a different matter. The speakers had dealt with that. There were, however, some other aspects of nuclear power activities that deserved attention. There was a considerable body of opinion that the pathways of radioactive materials in natural and forest systems ought to be studied more closely, if only to find out where they went. There was not a body of information in the UK that really gave a good picture of those pathways. Also, radioactive materials were extremely good tracers of the behaviour of a number of allied pollutants whose dynamics researchers dearly like to know and understand.

Mr.Barry Sheerman (Lliw Valley Borough Council) said that it was his first attendance at the Annual Conference and that he realised that such affairs often tended to be a little selfcongratulatory. However, he felt that he had to strike a discordant note on that during the discussion. His experience of the Conference so far had worried him a great deal for there was, he feared, an air of complacency hanging over the organisation, and while it might not have been a representative year, many of the things he heard had greatly disturbed him. That particular session had spotlighted the very real problems that people still faced in the fight for the environment, the quality of air they breathed and in turn its effect on plant life, trees and human beings. He had been particularly concerned the previous day when Mr.Holmes from High Peak district had come to the rostrum and singled out what he called the "pseudo-environmental" groups, criticising those as an interfering nuisance that could well be dispensed with. Mr.Sheerman wanted to make the point that conference had heard about major problems that still existed in abundance and in the previous two days many people had talked about how much had been achieved in the battle to cut down the amount of sulpher dioxide affecting the urban environment. At the open session, on the other hand, Professor Last had made the point that there was still the same level of sulpher dioxide being emitted as in the worst days of the great fogs, but it was falling in a rather different pattern, perhaps falling on the Continent rather than in the UK His question for the panel was what they thought a realistic programme for action for the future of the environment in the UK ought to be. There ought surely to be, he thought, a strong link between universities, pressure groups (such as the National Society for Clean Air), political parties, politicians and government, in a co-ordinated attack on the problem. His own view was that there was not enough linkage between the university world,

the world of scientific research and the active world of politics and government. In part, he felt that the responsibility for this lay with the National Society for Clean Air, which had become to an extent rather complacent about the problem and the work that still needed to be done, especially as new problems and threats arose. He believed that in the last ten years such organisations as The Friends of the Earth, the Socialist Environmental Resource Association, the Campaign against Leaded Petrol, had all in their way taken over the job which the NSCA should have been doing. The National Society had been by-passed because it had been unable to respond to the mounting problems of pollution on our planet and he hoped that the afternoon's speakers, who had been so stimulating, could discuss his points.

Professor Whittingham, replying to Mr.Sheerman, said he had spent many years working in universities and he could reassure the questioner that today there was good liaison bewtween research in the universities and the problems of applied science. Concerning research in aerial pollution there was an effective exchange of information and he believed that the present limit to progress was the lack of resources. In the past the money committed to supporting research in the UK on aerial pollution had been minimal; the situation was changing but one might question whether it was changing fast enough. The present effort in research was well co-ordinated.

Professor F.L.Last, said that at the time he agreed with what Professor Whittingham had said but he certainly would not have agreed with him 5 or so years previously. There had been a very major change of attitude during that period with increasing numbers of University research workers choosing problems with a direct link to national social needs. Undoubtedly that change might have been accelerated by the attitudes of organisations awarding grants. The questioner had queried the interelation between 'research' and society. Undoubtedly government departments, major providers of research funds, could be influenced by public pressures. The attendance of Dr.Saunders and Professor Whittingham and Professor Last indicated that the NSCA had political muscle.

Dr.Saunders regretted that he could not add much on the subject. He did not feel he could comment properly on the future role of the Society except to say that the conference provided an opportunity for the people working in the various fields, such as air pollution control; he cited Mr.Fairclough's speech, from the ministerial point of view, as an example. What did rather worry him was that the field had got so enormous and so diffuse that it was not only the air pollution field that was discussed, but the pollution field as a whole. Often it was very difficult to decide on what the priorities should be, not only for research, but also for proselytising through the envangelical movements of pressure groups and organisations. There were difficulties sometimes for research administrators and scientists in trying to educate their opposite numbers among the politicians or administrators in government, on the problems and how those could be turned into practical policies and practical research objectives. Professor Last had been heavily involved in one experiment in which the NERC had set up various mechanisms to try and overcome those problems in the air pollution field. Dr.Saunders thought that his

colleagues within the Department of the Environment for instance, would probably agree that the experiment had been pretty successful on the whole; there was now a great deal of exchange of information. But how he asked, could the next step be taken to the pressure groups, to the parliamentarians? He did not see how the NERC could do that as an official organisation, except through its formal reporting systems. It had to be an organisation, like the N.S.C.A. that spanned a large number of interests, to get such issues by the throat, thrusting them at everybody concerned with such matters. As an outsider, Dr.Saunders believed that this was the role of the Society.

Miss Mary George (Chairman) said she would like to thank the 3 speakers for the way they had replied to that question. She also wished to say on behalf of the Society that it was certainly not complacent in its attitude to any of the new problems or possible hazards that were brought to public attention. She thought the speaker perhaps might be confusing complacency with caution and as a responsible Society with work over many years it did not make public statements or go into print without being quite certain that what it was going to say was backed up with reliable evidence; this perhaps was sometimes why it did not get the same amount of publicity as some other organisations who perhaps were inclined to rush in where angels feared to tread. It was not emotive in its reactions but it tried to base its statements and its reactions on fact. That was why the Society was grateful to the three speakers at the open session for having brought before the conference the results of very careful and valuable research in the various claims and statements that they made.

Mr.C.T.Savin -(B.P.Trading) said straight away that he was not talking on behalf of his organisation, but as a practising allotment holder. He pointed out that he also was attending the Conference for the first time but unlike the previous questioner he had come to the opposite conclusion. He agreed with previous commentators that some stimulating and interesting papers had been presented that afternoon, but it did seem to him on reading them and thinking about them that at the end of the day the only real conclusion made was that a lot more work and a lot more expenditure and, he supposed the members would say, a greater allocation of research funds, were required to find out more about those very cucial and fundamental problems. In that respect, he sided with Rear Admiral Sharp in urging caution before people plunged into arguments and pressed for instant solutions.

Mr.Savin wondered whether Dr.Saunders could explain on what evidence or based on what reasoning he had converted what had seemed to be perhaps a possible plus from atmospheric deposition in to a loss of 15%. He could not see it arising from the paper and in that respect he thought it would be helpful if Dr.Saunders would comment on Professor Mellanby's comment the previous day, when he had regretted that he could not be present for the open session, and able to cast doubt on the 15% figure.

His other question was addressed to Professor Whittingham, and he spoke then as an allotment holder. He revealed that when he wanted to produce plants and vegetables for prize showing, he protected them, and prevented

Dr.Saunders, in answer, pointed out that he had been asked to be controversial and he certainly seemed to have been by putting those figures in his paper. As he had said, it was a gut reaction based on certain trends that were developing in certain areas of research. Previously, he thought, it had always been assumed that the effect on agriculture, which was probably the easiest one to handle in terms of sulpher dioxide, was a balance between a positive and a negetive effect. There were recordings where sulphur was beneficial to the land and in fact there was even information from Norway to show that they had got the same positive effect. But if a number of other pollutants were looked at no benificial effects whatsoever were to be found. Ethelene around certain chemical plants, he feared, was quite a major problem, probably larger than had been previously. Ozone was going to be a very serious problem, in his opinion, in the next few years. Sulpher dioxide was on balance having an adverse affect, he considered, particularly looking beyond just agriculture, and into urban areas. His gut reaction was that if one assumed an optimum growth rate, then about 15% of that total plant production would be lost due to all forms of air pollution. But he wanted to emphasise, backing up what Professor Whittingham had said, that if one looked at the totality of other losses, such as diseases which in a year could account for 20 or 30% of the theoretical or optimum loss, then yield in any one year was no where near the optimum that could be produced from all plant forms. That was why, in fact, Dr. Saunder's estimated percentage field loss was studied, it bore no relation to the estimated economic loss. The theoretical economic loss would probably be thousands of millions, but all he had put down was really what he thought might be recognised as any form of damage that could be costed. He did not consider it a sound estimate; it was perhaps no more solid than PAU'S estimate had been a few years back or than one or two more recent estimates that he had seen. It was a guess, and purely that! He thought Professor Last had also mentioned the effects of wind and pollution that was another area where there were some rather alarming results begining to come through. The interaction experiments involving mixtures of pollutants had been giving rather alarming results and the next problem was to take those results into the field and then to translate them into real damage effects. He was still working to guesses based on the theoretical extrapolation of data from the laboratory to the field and then to the country as a whole. He made no claims that such guesses were accurate. However, he thought that a number of his colleagues felt the same way. Whereas about 2 or 3 years ago, they had been uncertain that air pollution had a negative effect , now an increasing majority of them were moving towards the view that the overall impact was on the adverse side. The losses were significantly worse than the benefits. But the problem now was to find a yardstick, an accurate yardstick of such losses, and that was really what all their work was designed to do, then and in the future.

Professor Whittingham, in reply to Mr.Savin, said that when research had

the wind blowing round them, watered them regularly and lo and behold he got a better yield than he did from the generality of his crops. He wondered if there was any evidence that the results of the experiment in Professor Whittingham's closed chambers showed any correlation with the prize growing syndrome.

begun at Rothamsted, he personally had had some doubt as to whether the techniques available for field experimentation would be sufficiently sensitive to enable them to measure the effects of aerial pollutants on cereal growth. In fact he had been surprised by their finding quite significant effects albeit during only two years study and he was encouraged to find that three other groups in the UK were obtaining results which were not dissimilar. Ten years ago it had been widely believed that effects of aerial pollutants on growth and yield would only be significant in the presence of visual symptoms. Now they were beginning to believe that effects may be quite significant even if there were no visual effects on the plants themselves. Many gardeners would know that even a small change in growing conditions could alter the quality and flavour of a vegetable crop. Relatively small changes in environmental conditions could influence plant growth. That in part had made more difficult the investigation of the effects of aerial pollution on growth under natural conditions because it was not simple to remove the aerial pollutants from the environment without also altering a number of other environmental factors.

Dr.Saunders said that Mr.Savin, commenting on research, had remarked that scientists would like to see a lot more research done. Dr.Saunders declared that the research organisations and research societies would like to see more research done! He had always to admit that they would like much increased funds. But he did not think that any of them would claim that an enormous increase was needed in this field because a number of problems had to be overcome. He thought that both his colleagues who were at the practical end of operations would agree that they could do with more money to do certain kinds of work. But one of the major problems was that there would not necessarily be the expertise or the equipment and facilities to go ahead on some new, enormous scale. To give a general idea, he explained that total expenditure on air pollution effects research by the government, mainly through the Research Councils and universities, was about £⅓m a year at the moment and that was a significant increase in real terms from about 4 or 5 years previously when the amounts available were about £30,000 or £40,000. Support was now just about reaching the level of saturation without duplicating work by new people coming in through the universities and elsewhere. On the other hand, in the case of the Agricultural Research Council and his own Council, they had built up groups within their own institutes and probably could take more work on, But they had to fight for that new work in terms of priorities with every other field of pollution research and every other field of research. In the case of his own Council (the NERC) the latter included for instance Conservation and Forestry Research. New research had to be looked at in that context. He was not using the discussion as a lobby to argue for more research, because it was not something that would be achieved overnight.

Mr.A.J.Clarke (CEGB - Chairman of NSCA's Technical Committee) took issue with one or two of the figures that Professor Last had included in his presentation, which he felt might give a misleading impression. In his first slide, Professor Last had shown a graphic illustration of the effects of a smelter accompanied by a scale of sulpher dioxide concentrations that Mr.Clarke found wholly unbelievable. There was an area of dying trees at an average SO2 concentration of 60 microgrammes per cubic metre. Mr.Clarke

did not believe that trees would be killed at that concentration; if so, a very large area of Great Britain would be full of dead trees. In fact, one of Professor Last's other slides had shown the trends in cencentration in North West England, where the winter concentration was around 100 or more microgrammes per cubic metre. If the previous figures were correct, the North West of England would not have any living trees in it.

When the Technical Committee had prepared the Society's booklet on SO2 pollution, some time had been spent looking at the evidence for trends in rural and urban concentrations. There were very few rural gauges, but it had been concluded that there was no obvious trend either upwards or downwards. The levels however were certainly very much less than those shown by Professor Last for North East England. Very large areas of England probably had annual SO2 concentrations of 30 microgrammes per cubic metre or less.

Mr. Clarke then referred to the suggestion in Professor Last's address that pollution problems were being solved in the UK by using tall stacks which dumped the emissions in someone else's country. This assumption was entirely wrong; the greater the height of emission the less the overall pollution produced at all distances; the effect at large distances being small in any case. Mr. Clarke displayed a slide showing the total deposition of sulphur from sources in the UK alone. Most of the emission still landed in Great Britain and there was progressively less deposition at greater distances.

A second slide showed the total deposition from all European sources which illustrated a similar effect. He explained that there was a small anomaly in the area of South Norway where the higher rainfall over the mountains (and only the higher rainfall) led to an enhanced rate of deposition.

In his view there was no evidence at all that the UK was exporting its pollution, and saving itself at the expense of other countries. The reason why the much higher rates of deposition in UK and Central Europe were less of a problem than in Norway was illustrated by a third slide. This showed the areas of Southern Norway in which there had been reports of effects on fisheries and lakes and also, the areas that had alkaline bed rock which would neutralise the acid. The two areas did not coincide. The acidity was thus having more effect because the bed rock was not there to neutralise the acid. Very much higher levels of acidity in rain falling elsewhere had less effect because the great majority of bed rock was of calcium which would neutralise the acidity.

The policy adopted in the UK for the control of pollution by sensible height of stacks was not one which was causing long distance effects. After the plumes had travelled about 20 to 50 kilometres the height of emission became totally immaterial and the emissions were uniformly distributed throughout the mixing layer. It made little difference to the ultimate effect in Norway. Any statement that the UK was exporting its pollution problems by the use of tall stacks was one which needed to be refuted and in fact the OECD report itself did that.

Professor F.T. Last wondered at which stage of his talk he had referred to the export of pollutants? Instead he had emphasized the existance of two pollution senarios, (a) near to sources of emission, where SO_2 was the predominant sulphur pollutant whereas at a distance particulate SO_4 came into its own and was of significance in relation to acid precipitation with possible direct and indirect effects on forests. Acid precipitation, not solely attributable to sulphur pollutants, had been shown to affect some (a) aspects of tree physiology and (b) soil processes in laboratory-type experiments. As yet there was no unequivocal evidence of damage to forests but the fate of the continuing inputs of pollutant sulphur ought to be examined.

Mr. Clarke had taken him to task about two specific details of his talk. In following the accepted code of practice, he had referred to the Warren Spring Laboratory's "National Survey of Air Pollution" using the designation ANON simply because specific authors were not identified. The absolute concentrations of SO_2 in N.W. England might be typical but the time trends, which he had gone out of his way to stress, were characteristic of most of Britain; urban concentrations of SO_2 were decreasing but not those of rural areas.

RADIOACTIVITY AND THE NUCLEAR FUEL CYCLE

Dr. Roger H. Clarke
Berkely Nuclear Laboratories, CEGB

THE CONTROL OF AIRBORNE RADIOACTIVE EMISSIONS FROM NUCLEAR POWER STATIONS IN THE U.K.

J. Beighton
H.M. Deputy Chief Alkali and Clean Air Inspector

EXPOSURE OF THE PUBLIC TO RADIOACTIVE DISCHARGES FROM THE NUCLEAR FUEL CYCLE

Pamela M. Bryant
Senior Environmental Adviser, National Radiological Protection Board
and
Frances E. Taylor
Senior Scientific Officer in Environmental Studies Group, National Radiological Protection Board

Mr. R.B. Pepper (Principal Health Physicist of the CEGB) opening the discussion, admitted that being an employee of one of the organisations responsible for the release of radioactive materials to the environment did not necessarily make him the most desirable choice of first speaker. However he had been encouraged by the content of Mr. Beighton's and Miss Bryant's papers in that he believed they demonstrated convincingly that the emissions from nuclear power stations were well controlled.

He reminded the audience that Mr. Beighton had spoken of the care that was taken over the clean up of gaseous effluents at these stations. A variety of techniques were utilised which included centrifuges, ceramic filters, pre-filters, absolute filters and iodine removal beds. In addition to the provision of this sophisticated treatment plant, a routine programme of checking existed to ensure not only that the filters were up to specification, but that their installation remained sound and that no leakage was taking place around sealing gaskets etc. Mr. Pepper suggested that this very responsible attitude was one which could well be emulated by other industries.

He drew attention to the discussion in the papers to the limits to radiation exposure recommended by the International Commission of Radiological Protection. Perhaps the most interesting feature was that relatively little emphasis was placed on these limits. Instead, most of the discussion centred around how far below these dose limits the stations were operating and he referred to the fact that current design standards within the CEGB required that the emissions should lead to doses not in excess of 1/20th of the limits. Furthermore, since it was intended that no one person should receive more than 1/20th, other exposed persons would get considerably less than this and their dose may well be 1/100th or an even smaller fraction of the recommended upper limit.

Mr. Pepper drew the audience's attention to the way in which evironmental monitoring had been discussed in Mr. Beighton's and Miss Bryant's papers. The former had suggested that the purpose of environmental monintoring was

to demonstrate that any emissions from the site were not causing any undue increase in radioactivity around the station. Miss Bryant however had made the point that few environmental monitoring programmes were designed to enable the actual doses to people to be estimated and she considered that this was something which should possibly be aimed for. Mr. Pepper went on to question whether there was any great virtue in extending the sensitivity of measurement on environmental samples when one could demonstrate relatively simply that the levels of radioactivity were less than, perhaps, 1/20th or 1/100th of the recommended ICRP limited. He feared that environmental monitoring programmes designed to enable doses to be estimated with reasonable accuracy could increase cost and he suggested the speakers might care to discuss that aspect further.

He noted that in none of the papers had any reference been made to the combined effect of discharges from more than one establishment. He believed that this was an aspect which justified some further explanation and discussion. Was a rationing system likely to be introduced? If so, who was to be given the responsibility for stating the size of the rations? Mr. Pepper also noted that Mr. Beighton, representing one of the Authorising Ministries, had made no reference to collective dose in his discourse, but that both Dr. Clarke and Miss Bryant had referred to this in some detail. It appeared that there were no limits recommended for collective dose; this was another aspect which might benefit from further explanation by the main speakers.

Mr. Pepper concluded by re-iterating the data which had been put forward by Miss Bryant. In round numbers, she had said that on average every person in the UK received 97 millirem per year from natural radiation. On average every person in the UK received approximately 14 millirem per year from medical X-rays. On average every person in the UK received approximately 2 millirem per year from bomb fall-out. On average every person in the UK received only 0.2 millirem per year from the activities of the whole of the nuclear power industry and the contribution from gaseous emissions from nuclear power stations contributed only 0.007 millirem per year towards this. That, claimed Mr. Pepper, was a very good illustration of the responsible way in which emissions from nuclear sites were treated and discharged.

Miss M. George (Electrical Association for Women) said delegates had been fortunate in hearing the assurances and the notes of caution that had been sounded by the Speakers in a relaxed and unemotional atmosphere. But when trying to convey to the general public some of the information that had been given it was important and sometimes very difficult to strike the right balance between complacency and caution. She wished to suggest that at a subsequent Conference the Society might consider including a follow-up session devoted to the problem of public communications. The Association that she represented, the Electrical Association for Women, was about to embark on a public relations exercise on the subject of nuclear power generally and she was sure the Association would be happy to contribute to such a session.

Mr. N.J. Davis (Forest of Dean D.C.) said that Dr. Clarke, in particular,

had talked about fission. As he understood it, there was another form of interchange, namely fusion. He asked whether Dr. Clarke foresaw at any time the possibility of fusion being used for the generation of power or was it literally as well as metaphorically, too hot to handle.

Councillor M.G. Caulfield (Chesterfield Borough Council) thanked the Chairman. He said that he had come to the platform neither as a nuclear physicist or a scientist, just as a local councillor, and he spoke from the layman's point of view. He found the Conference very interesting, and in particular, that morning's session. He was worried when he heard of pollution and the limit of pollution, of minimum and maximum levels and justifiable levels; but the question he would like to ask the panel was, was this the first bit of the cake or the last, or were they going to gnaw away until the day when there would be zero or no fall-out from literally any source.

Dr. R.H. Clarke replied that while much was known about the physics of fusion, it had not yet been possible to demonstrate in the laboratory that fusion power was a viable proposition. He said that it was quite conceivable that in the next 50 years, a fusion reactor might be made to work, and the potential energy source would be vast, but there would still necessarily be associated radioactive discharges. These would be different from the ones originating in a fission reactor programme and might be of less radiological significance, but this would emerge as time went on.

Miss P.M. Bryant said that she would like to comment on the point made by Mr. Caulfield with respect to a re-assurance that one day there would be no radioactivity discharged from the nuclear fuel cycle. She said that the concept of zero release was not feasible and that there was no human activity without risk. The only event for which there was a probability of one was that of eventual death; everything else had a probability of something less than one. Miss Bryant said that it was up to the industry, up to everyone in life, to make their assessment of an acceptable degree of risk. The probability of some effect might be as low as 10^{-4}, 10^{-5} or 10^{-6}; the nuclear industry was trying to keep the risk of effects from discharges down to very low probabilities. The nation had to decide whether it wanted power of some sort and how it wanted to obtain that power, for example from coal with attendant risks, such as killing of miners and causing pollution with sulphur dioxide. Subjective and, if possible, objective judgements had to be made on the relative merits of all the courses of action.

Miss Bryant went on to the subject of collective dose; the reason for not having a limit was that collective dose assessment was part of the process of optimisation. What one had to do, following a decision to generate power by nuclear means, was to carry out differential cost benefit analysis. This meant that first one assessed the cost of putting in extra clean-up plant; then one assessed the cost of not doing so, in terms of the additional collective dose incurred by the population. The cost of one man rem was probably about 10 to 100 dollars. A judgement could then be made on whether the benefit of installing the extra plant exceeded the detriment to health of not doing so.

Miss Bryant then said that one recommendation in the UK policy on waste disposal, as set out in Command 884 in 1959, was an overall limit of one rem per generation; this was, in effect, a limit on collective dose because it referred to the average dose to the population as a whole. The Department of the Environment had set up a body which was reviewing the waste disposal policy in the UK. Mis Bryant could not anticipate its conclusions but it was likely that account would be taken of the stress that the International Commission on Radiological Protection placed on the optimisation procedure and it was unlikely that a collective dose limit would be specified.

Dr. Clarke, trying to re-assure Mr. Caulfield a little, said it was necessary to remember that radioactivity was a natural phenomenon. People were all irradiated all the time, and perhaps the disadvantage which radiation suffered from was that radioactivity emissions from nuclides were like fingerprints for elements: with a fairly simple detector any single isotope could be detected, so that, when looking at nuclear discharges, it was possible to 'fingerprint' every single thing right down to very very low levels, which was not a practice that was necessarily done with non-radioactive pollutants. Thus it was possible to measure very low levels of radioactivity. The other point that he wished to make to Mr. Caulfield was that assumptions made about the effects of radiation were extremely conservative. Dr. Clarke thought that although Miss Bryant had already emphasised that, it did not hurt to say again, that the evidence for the harmful effects of radiation was always obtained from people exposed to very high levels of radiation at high dose rates and a very conservative assumption was made that the CEGB's low level discharges which, as had been said earlier, could be monitored, had a proportional effect.
Dr. Clarke believed the nuclear industry to be more responsible than perhaps people who discharged non-radioactive pollutants.

Dr. R. Coates (British Nuclear Fuels Limited) had two questions on details to put to Mr. Beighton, concerning the joint authorisations for radioactive discharges, which Mr. Beighton had said were jointly the responsibility of the Department of Environment and the Ministry of Agriculture. He asked him to comment on the role of the Radiochemical Inspectorate in that particular position and its relationship with the Alkali and Clean Air Inspectorate. His second question was a general one which he thought Dr. Clarke might be able to answer. A certain amount of radioactivity came from fossil fuel power stations: was it possible to assess the magnitude of these, and any contribution to dose that they might give people.

Mr. Beighton answered Dr. Coates first. He thought that Dr. Coates was trying to understand a little better how the Alkali Inspectorate worked in relation to the Radiochemical Inspectorate and within the joint authorisation procedure which had been mentioned. This puzzled Mr. Beighton a little because he had not thought there had been much room for doubt or misunderstanding here but he was quite prepared to explain the point further. The Radiochemical Inspecorate, as he had indicated, was within the Department of Environment. The Alkali Inspectorate worked very closely with the Radiochemical Inspectorate in matters concerning assessment of proposals to discharge airborne active waste. The particular expertise

he would claim for his Inspectorate was one in chemical engineering. That was the speciality of the Alkali Inspectorate and the expertise of the Radiological Inspectorate, he suggested, lay more in radiology. The two inspectorates worked together: the Alkali Inspectorate obtained help and advice from the Radiological Inspectorate, they consulted with each other on the question of airborne emission control and between them, they worked to the DOE or the Welsh Office in their functions as departments concerned with deciding whether or not to issue an authorisation. In effect, the two inspectorates were a technological unity working together within the framework depicted in his paper. They each needed the other and a better result was obtained by this co-operation.

Turning to Mr. Pepper's question concerning environmental monitoring, he said he had tried to indicate in his paper, referring to the best practicable means and authorisation requirements, that monitoring was necessary at least to detect any changes in the environment, whatever else might be in doubt as to how far this could be used in more exotic ways. Even though one might go on reading a mass of data which indicated that there did not seem to be any effect on the environment from this or that emission, he doubted very much, in terms of public opinion and politics generally, whether one could argue a case for not doing it. He felt sure in his own mind that if there was a nuclear power programme, the public did need reassuring and they wanted to be able to understand that the authorities had checked the effect on the environment. If it was necessary then to say "we've checked and we can't find anything", that was all right, that answer would be fine. It should not lead to complacency, nor would it negative the case for checking. People needed to be satisfied and wanted that information but at the same time the work had to be paid for by someone and providing that was accepted as a necessary part of the insurance factor, then there was a case for doing it.

Referring to Professor Scorer, who had wondered whether he might comment on the long-term issues involved, he was naturally cautious about crystal-gazing, and did not intend to do any. He thought it much better to remind delegates of the bulky Sixth Report of the Royal Commission on Environmental Pollution. The Commission had commented and reported on a large number of factors within that context and a number of those things had been answered and commented on by the Government in their response to the Sixth Report. That had been mentioned in the references in his paper; they had gone into quite some detail on the sort of thing Professor Scorer was concerned about. On page 6 of the Government's Response, there began a section on the management of radioactive wastes and it was mentioned, for example that the Government accepted that an overall long-term strategy was needed and that waste disposal considerations needed to be taken fully into account in the design of nuclear systems. It indicated that in accordance with the Royal Commission's recommendation the Secretary of State for the Environment would in future be responsible, together with the Secretaries of State for Scotland and Wales, for nuclear waste menagement policy. The main elements in that new responsibility were itemised. So he suggested that delegates should consult both those documents and he thought they would get a fair amount of help from them on such enquiries.

Councillor H. Daley (Wakefield M.D.C.) was glad that Mr. Beighton (who was the only speaker to have touched upon the Royal Commission's Report) had referred to it, because there appeared to him, speaking quite simply as a layman to be a degree of complacency settling over the conference which was illfounded and unfounded and when the Chairman had asked for "them to expose themselves to our gaze" as he had put it, Councillor Daley considered that the Royal Commission on Nuclear Power and the Environment did just that. But it seemed to him that some of the speakers from the platform that day had ignored it and rather wished that it did not exist. Mr. Daley thought that the speaker who had referred to the fact that there were risks with all energies had been quite correct. The big difference, as he saw it, was that the risks from all the energies that were known: coal, gas and oil, were controllable risks and were controlled. That could not be the case with the new power that was being discussed. With nuclear power there was no proof, there were no prospects and no certainty that it would be controlled in the way that the risks in the normal forms of energy were controlled.

Mr. Beighton had referred to the report on radioactive waste. Councillor Daley wished to draw attention to paras. 265 and 266 of the report on the effect of the release of that waste, which had not been touched upon. He asked delegates to read and consider them.

He quoted from the report, Para. 178, (since Mr. Beighton had seen fit to do so) "We must assume that these wastes will remain dangerous, and will need to be isolated from the biosphere for hundreds of thousands of years. In considering arrangements for dealing safely with such wastes, man is faced with time scales that transcend his experience". This was a very philosophical, provocative statement that declared "here we are on the fringe of something". Yet, speakers seemed to be saying that all was settled, people could sleep safely in their beds, there was no problem at all, and it was in an attempt at least to alert the Conference to the idea that there might be another side to the argument that Councillor Daley had decided to speak. He concluded by asking Mr. Beighton questions on his statement that he consulted with local authorities on the release of nuclear gaseous wastes: with whom did Mr. Beighton consult in the local authorities? Was it the Public Health sector? Was it the Chief Executive? Or was it the elected members of the Council? It was, he felt, a very important question. He thought that when such waste releases were being put into the atmosphere people who were connected with local authorities and were accountable to the public, should also be informed of what was being done.

Mr. Beighton said that, having been allowed only 30 seconds for reply he could only endeavour to answer Councillor Daley quite briefly. He explained that the Alkali Inspectorate themselves did not visit local authorities in terms of their work under the Radioactive Substances Act; they worked as agents to the departments already mentioned. They made reports to the latter. There was however, the liaison committee framework and DOE for example sent representatives to the liaison committee meetings and they provided paper information. The Alkali Inspectorate were available to attend meetings if required or if there was anything particular that they should discuss. In effect it was essentially a face to face liaison between the authorising department in an administrative way and a local authority. He

had never attended such a liaison committe meeting himself and he was not sure of the local authority membership. He assumed it was in some way a composite make-up, of maybe the Public Health Department and an elected representative. He though perhaps delegates from authorities who had those installations in their area might know more than he did because they maybe went to such committees.

Miss Bryant said that she agreed with Councillor Daley that not all problems were solved. The subject under discussion at the Conference was the environmental effect of nuclear power in relation to routine dishcarges. She agreed that that cut out a tremendous number of subjects, including long term disposal of high activity waste, which the Conference had not had time even to start to think about. Some problems gave cause for concern, in that the right solutions must be found and decisions could only be taken when a great deal more information was available.

Dr. Clarke said that, with just 30 seconds for speech, he could only volunteer to stay behind after the session and talk in detail to those who were interested. In reply to the question about fossil fuel plants, he explained that there is radioactivity in coal and radioactivity does come out of conventional power stations. If anybody wanted to talk about this, Dr. Clarke would discuss it further. The Royal Commission Report he thought, said that to abandon fission power would be neither wise nor justified and that its main concern was over any immediate large scale expansion. He said that his feelings were quite different from Councillor Daley's but he was quite happy to talk to him after the closing session.

INDEX TO SPEAKERS

NATIONAL SOCIETY FOR CLEAN AIR

44th CLEAN AIR CONFERENCE

SEPTEMBER 19 - 22, 1977

HARROGATE

CLEAN AIR - SOME RANDOM THOUGHTS ON THE STATE OF PLAY

T.H. Iddison
Chairman of the Council of the
National Society for Clean Air

136 North Street
Brighton BN1 1RG
England

CLEAN AIR - SOME RANDOM THOUGHTS ON THE STATE OF PLAY.

The Domestic Situation

Smoke control orders and changed patterns of life have resulted in quite dramatic reductions in smoke pollution of domestic origin but the situation is patchy and there is no room for complacency. Whilst the London Boroughs with a target of over three million premises, by far the largest of any region in the Country, by no means the dirtiest, have achieved 96% of their target, no other region has yet reached more than 65%. It is noteworthy that the regions with the lowest targets are the ones that have done least to achieve them. Not only have they been slow, but some appear to have made no progress since local government re-organisation. The time is ripe for a great renewal of effort. The brief moratorium in relation to the confirmation of smoke control orders has been lifted, and there never was one in relation to the declaration of areas. Some local authorities, and some local authority officers, have expressed a wish that central government should have placed more emphasis on the need for expenditure on smoke control, whilst others repeatedly urged that there should be less direction from Whitehall. We can't have it both ways. As things stand local authorities are free to decide their own order of priorities and I can think of no field of district council expenditure which provides such a great return for <u>all members of the community</u> for such a modest outlay.

I emphasize "all members of the community." There are now, and have been for some time, ample supplies of solid smokeless fuels, and grants should only be paid in respect of conversions or replacements of appliances necessitated by the making of a smoke contol order. Improved amenity and other benefits are so obvious that it should not be considered necessary to popularise smoke control by the making of lavish grants in respect of the replacement of all the heating appliances in ground floor rooms, irrespective of their degree of use, by alternative forms of heating which the occupier considers more convenient.

It is a great mistake to think that only areas in need of smoke control are the industrial ones. Any area of pre-1950's housing of any size merits careful consideration in relation to the need for smoke control measures, and it costs nothing to make all new major housing development smokeless from the outset.

During the last year increasing concern has been expressed, particularly by solid smokeless fuel interests, in connection with what is alleged to be a noticeable increase in the sale of bituminous coal in smoke control areas and the effect that this is having on the cleanliness of the air in those areas, and thereby on the reputation of smoke control areas. The matter has been discussed by the Clean Air Council, by this Society, and by the Environmental Health Officers Association. There is little concrete evidence to suggest that the practice is very widespread. There is evidence to indicate that enforcement authorities are very frustrated by the inadequate sanctions that they have been able to impose, particularly the levels of fines that have been imposed when proceedings have been successfully instituted, levels which act as no deterrent to the guilt merchant.

The Department of the Environment is to make an approach to the Lord Chancellor's Department in relation to the level of fines, and through their association environmental health officers are to collaborate with the fuel industry in such a way as to ensure that guilty merchants are unable to obtain supplies of fuel through normal trade channels.

The Industrial Situation

There have been steady improvements in relation to the control of emissions from registered processes as a result of the application of "best practicable means". (For details see the Chief Alkali Inspectors annual report). It is unfortunate that there does not seem to be any sense of urgency in dealing with the uncertainty as to where the responsibility for enforcement should lie or as to the desirability or otherwise of implementing the recommendations of the Royal Commission in relation to the setting up of a pollution inspectorate at Central Government level to deal with, or advise upon,pollution of all forms and to try to secure in every case the best environmental option.

In so far as non-registered processes are concerned local authorities are achieving a very satisfactory standard of enforcement of clean air legislation, by co-operation with the industrialists in most cases, and by prosecution where other approaches have failed. Neither the standard of compliance with the law,nor the standard of the enforcement of the law can be assessed solely by the number of prosecutions taken and the number of statutory notices served. With the association between environmental pollution and conditions at places of work which arises from the implications of the Health and Safety at Work Act, both the Alkali Inspectorate and environmental health officers may increasingly find themselve in danger of departing from their traditional approach in the face of pressures from the Health and Safety Executive to whom such statistics appear to be the only acceptable criteria. Those with an interest in local authority enforcement will find information in the Annual Environmental Health report of the association.

Concerning non-registered processes, the Regulations regarding grit and dust emissions will apply to existing furnaces with effect from January next and should facilitate the introduction of adequate control measures in cases where they do not already exist. The circular which accompanied the measurement regulations emphasized the need for discretion in relation to the service of notices, as did the one which accompanied the regulations concerning the obtaining of information upon emissions by means of the Control of Pollution Act procedure. This advice should not be used as an excuse for doing nothing when it is clear that something needs to be done. There is a danger that if the local authorities fail to use their powers they may well be placed in other hands. The provisions of the Health and Safety at Work Act in relation to emissions to the atmosphere could be used to make Regulations for either Central or Local Government to implement.

Air Pollution arising from Agricultural Practice

The Royal Commission have been asked to consider the situation of agriculture in relation to Clean Air legislation. Problems in this

connection that the Society is aware of are generally related to the disposal of agricultural waste, such as straw and stubble burning and tree burning assisted by old rubber tyres. Odour problems associated with the disposal of animal wastes will also be considered.

Pollution from Road Traffic

The number of vehicles on the road continues to increase. The proper use of planning procedures to control traffic flow, parking, and pedestrian areas could go a long way towards providing an effective means of control. To be effective there will need to be the closest co-operation between planners, environmental health officers, and in some cases the alkali inspectorate. It is illogical that emissions from motor vehicles should be regarded as mainly safety matters, and therefore, together with noise, subject to the control of police authorities. Perhaps this is another area for consideration by the Royal Commission.

Monitoring

From the information supplied to Warren Spring in response to its questionnaires on monitoring it appears to me, and I must emphasize that this is a personal view, as are the others that I have expressed, that in the past exercises in monitoring have, in some instances, been embarked upon without sufficient attention being paid to their need; e.g. whether information sufficiently reliable for the purpose could not have been adduced, or deduced by other means and without measurement. Also it would appear that in some cases insufficient thought has been given to the meaningfulness of the information to be obtained, e.g. whether the methods of collection or examination were such as to make possible a comparison of the results with an accepted standard, or with the results obtained by other workers in the same field. It is possible that failure to have regard to these aspects has resulted in a lack of confidence in the information obtained, and a reluctance to make the results available for publication. The fact that there is an Air Pollution Monitoring Management Group upon which there are representatives of Central Government departments, and all levels of local government, does not appear to be sufficiently widely known. Properly used it's potential is enormous. Failure to make use of it could result in the waste of a lot of time and money.

NATIONAL SOCIETY FOR CLEAN AIR

44th CLEAN AIR CONFERENCE

SEPTEMBER 19 - 22, 1977

HARROGATE

THE SOCIETY AND ITS FUTURE

Rear Admiral P.G. Sharp
Secretary General of the
National Society for Clean Air

136 North Street
Brighton BN1 1RG
England

THE SOCIETY AND ITS FUTURE

The theme for this Conference is "Why Clean Air?" and it is therefore fitting that consideration should be given to the Society, what it has achieved, its present role and that in the future.

Unfortunately, there is sometimes a tendency in days of financial constraint such as those we now live in, when thinking of the Society to examine its finances and resources. This is especially so at those times when the Society's 'trading position' has suffered as it did two years ago, and when it is not unusual for fears to be expressed about its future. I would suggest, however, that important as finances are, we should always remember that the Society's profits are not expressed as dividends paid to its members but rather as achievements in helping to make the air cleaner, not only for its members, but for all mankind.

The role of the Society since it was founded some 78 years ago has, in essence, remained unchanged. It is the promotion of clean air. This is not to say that the Society, at the same time, should not be run on a sound financial basis but it is equally essential that it should be recognised that the Society is a non-profit making organisation and its object is not to lay-up vast reserves for clean air in the next world, but to use its resources to achieve clean air for all in this world. The Society is registered as a charity and to use the old adage, charity should begin at home: but we must also recognise that there are some countries which have not made the same progress that we have in cleaning the air and that there are others who are only now emerging as industrial nations. So as well as watching our interests at home, we should also be prepared to help others by pointing out the mistakes from which we have learned and, at the start of their industrialisation to help others to control emissions to atmosphere from the outset. We have a great wealth of knowledge in this country; we should be ready to export it.

Mr. Iddison has just reviewed the position as it exists in the United Kingdom today. Tomorrow we shall hear papers from Professor Lawther and Professor Mellanby about the effects of air pollution, and in the afternoon we shall consider, in rather more detail, the achievements in both the domestic and industrial fields. I think that as a result few will doubt that although much has been achieved, there is still quite a lot to be done.

On Wednesday, Conference will discuss the EEC's environmental programme and its possible effects on this country; and on Wednesday afternoon we shall learn that although there have been many important discoveries made about the effects of aerial pollutants on plant life, there are still problems which have not been solved.

The Society while never losing sight of its main aim, the promotion of clean air, has in the course of its history been concerned with many facets of this particular philosophy. Certainly, during the last 20 years, it has advocated a fuel policy and in more recent times has advocated fuel conservation as this is one of the means of promoting cleaner air. We are

now faced with an energy problem if not an energy crisis and there is currently debate, often emotive and sometimes uninformed, about the energy gap, if indeed there is one, and how this should be filled. It is therefore appropriate that on Thursday morning Conference should debate the use of nuclear energy.

This may be said to be a far cry from the first, perhaps more limited aim of the Society to abate coal smoke. Nevertheless, the main aim has remained the same for nearly 80 years although inevitably there have been changes of emphasis. Time will not allow an examination of all the Society's many achievements, nor is there time to debate whether or not the cleaner air which we now enjoy in this country would have been achieved without the work of the Society. But I believe that history will show that the great efforts, many of which at the time seemed fruitless, made by the Society to create an informed public opinion prepared the way for the clean air legislation which we now enjoy. Indeed, the drafting of the first Clean Air Act of 1956 was largely the work of the Society, and again in 1968 the Society was very much involved with the preparation of the 1968 Act. The work of the Society is on record as being responsible; the Society's suggestions have been well reasoned and reasonable.

Because of this record, there has been a subtle change in the way that the Society has operated. Although by no means reluctant to express its views quite forcibly when this is necessary - and indeed over the years the Society has made a number of suggestions which have since become law - latterly there has been a tendency for Government to consult the Society and seek its views on future legislation and the control of air pollution.

In 1974 the Society extended its terms of reference and it now concerns itself to some extent with all forms of pollution. This was a logical progression as it came to be realised that the solution of one problem could cause another. The control of one form of pollution could lead to pollution in other forms. Incineration is one example of this; incineration used to get rid of solid wastes, can, if not properly controlled, cause air pollution. The scrubbing of gases is another. This has sometimes resulted in liquid effluents being discharged to rivers and streams so causing water pollution. In other words, control of air pollution is only part of the whole.

Then there was the realisation that noise constitutes a form of air pollution and that this is becoming of increasing importance. This widening of the Society's horizon has affected the Society's role and its future. Nevertheless, the main aim is still the same; the differences are in emphasis.

As the air has become clearer, if not cleaner, and more people have become aware of their environment, there has been a tendency for the media to select certain problems and sometimes to magnify these out of all proportion. CFCs and aerosols are one; asbestos is another; heavy metals - lead in particular,constitute a third. The public are bewildered and confused and do not know what to believe. In this the role of the Society is clear and unchanged; that is to tell the truth, to put such problems into proper perspective and to inform the public accordingly. Some years ago,

the effect of air pollution on health was directly concerned with the cardiac and respiratory systems; now, the problem is perhaps more one of stress - stress caused by worry about the effects of pollutants such as lead and asbestos to say nothing of noise. The Society's role continues unchanged - to seek to abate pollution and to tell the public the truth.

The question has been asked if there is a future for the Society; is there any need for the Society any more. I am in no doubt that the Society still has a role, and that there is still work for it to do, but its approach will inevitably change to meet changing requirements although there is still a need for smoke control; there are still laggard authorities.

We still hold an annual Conference; and although there are not as many people here as there might have been a few years ago, this does not mean that there is no need for a Conference. There are still problems for Conference to discuss, problems such as "Why Clean Air?". But to keep up with modern requirements and to keep abreast of developments in technology, we instituted, very successfully, annual technical Seminars as well as Conferences. Next year, however, instead of a seminar we shall hold a "workshop" at Bristol University to discuss planning and the environment. In addition, we are instituting a number of one day 'teach-ins' in various parts of the country as a means of fulfilling our role of disseminating knowledge and promoting clean air. The rising generation must be informed about the problems which exist and must be encouraged to realise that the solving of such problems in the future will be their responsibility. Here still lies our role.

NATIONAL SOCIETY FOR CLEAN AIR

44th CLEAN AIR CONFERENCE

SEPTEMBER 19 - 22, 1977

HARROGATE

THE EFFECTS OF AIR POLLUTION ON HEALTH

Professor P.J. Lawther
Medical Research Council

136 North Street
Brighton BN1 1RG
England

It was very reassuring on reading the pre-prints of my fellow speakers, to find that all that I have to say, in my cynicism and scepticism, about the present day scene has already been said, and to good effect. In being critical of some current work or in being critical of the general refusal to be happy about the improvements, I am not being negative, but it pays us to look very carefully, as a mature society, at the current state of the art. I have said to this Society before, and say again, that I think there may well be enough medical knowledge available to hand over most of the problems of air pollution,except in details, to the engineers and the legislators. I have said before that it is possible that some politicians may welcome the frequent sight of scientists scrapping about technical details, because it often enables them to postpone effecting radical alterations to our environment. For example, if you are very worried about lead and carbon monoxide in city streets you can abolish them if you have diesel operated public service vehicles instead of petrol driven cars. This is an uncomfortable thing for people to think about.

I have recently had the doleful task of going over several "criteria" documents again and I am saddened by them, inasmuch as they often refuse to look at the value of simple practical means and instead try to erect criteria or standards on the basis some very bad "science".

I think you will agree that to investigate properly, on a scientific basis, the effects on health of an air pollutant, you must approach the problem in a disciplined manner and I would suggest that one should look at it, first of all, to identify, either by clinical observation or by epidemiological studies that a hazard exists. The notorious example of this was the increases in mortality and morbidity seen during the so called smogs of 1952. Epidemiological techniques reveal such things as, let us say, an excess of stomach cancer in the north west; the wonderful new science of geographic pathology or analytic epidemiology is one where you observe, get some leads and then plan a formal investigation. You can then set up your epidemiological survey and your experimental method and proceed along scientific lines. The epidemiological technique, has the supreme advantage that it is concerned with man, in real life, but it is subject to various errors. The experimental method, of course, has weaknesses as well and one ought to combine the two. The epidemiological method has the weakness in that it deals with groups and unless you get a dedicated epidemiologist who is also clinically alert, you may find that you are being submerged in the analysis of the group, and forget that it is composed of individuals some of whom may react to stimuli but whose reactions are too few or too slight to be revealed in group analysis. It requires humility or common sense to look at people as individuals as well as groups, and find the truth.

The experimental model is subject to gross abuse, as is well known. In animal experiments, translation is made from one species to another; species differences are often gross: (a rabbit can eat deadly nightshade without effect). But I think a more neglected error in the selection of animal experiments is a neglect of their simple geometry. If you are looking at the fate of a particle going down a wet tube, any chemical engineer will tell you of the need to know the dimensions of the tube:

dimensions of size, temperature, humidity, etc. are important. So the limitation of the animal experiment is determined I think by the intelligence of the experimentor selecting the proper model. It is odd and regrettable that such simple things are ignored. What value is an air quality criterion for carbon monoxide, which is based, not solely but in part, on the time taken for a rat to drown after it is thrown into a bath of water and subjected to various concentrations of carbon monoxide. A rat has much less blood than I have and therefore it equilibrates with carbon monoxide far more rapidly than I do. If one steps back from this absurdity, one remembers that this very fact of difference in scale was exploited to good effect in the old days, when miners took canaries down the pit; the canary keeled over on its perch when it got saturated with carbon monoxide and this happened far more quickly than in the case of the miner, enabling him to get out; but these common sense views seem not to prevent people making false and dangerous extrapolations.

The experimental technique in man is, of course, limited by ethical considerations. We do all our experiments on ourselves or on healthy volunteers. It would be improper to do any but the slightest experiment on sick people (who are, incidentally, the proper subjects for our research) or on 'captive' populations such as students.

Taking various pollutants which are selected by WHO & EEC for special mention, we have of course, the most notorious SO_2 and the particulate matter. Here is a classic model of the way that I have suggested these things are looked at. A clinical syndrome, wheezing, shortness of breath, death if you like, is identified among certain of the population. Two irritants were obviously suspected, SO_2 and "smog" (in 1952 when I began research, the presence of water droplets was considered essential, and the miasma was called "smog"). It seems rather strange to look back now and see that probably the first bit of reasonable work I did in this field was a simple experiment with the diaries which demonstrated that water droplets were not necessary and that it looked as if it was a combination, apparently of smoke and SO_2, (or either alone) which was harmful. We have been singularly unsuccessful in demonstrating formally what was the particular irritant which was responsible. It would seem that from refined techniques which we have been able to apply to ourselves, we can make one part of a million of SO_2 produce increased resistance in our airways as long as we force the gas down us. If we breath quietly we see no effect but if we add 4% carbon dioxide to the mixture to make us hyper ventilate then we increase the velocity of the gas we inspire and force it down the respiratory tract so that it hits receptors which it would not otherwise do; in quiet breathing we assume it is scrubbed out in the warm moist upper part of the respiratory tract. It would, therfore, be reasonable to say that we can demonstrate alterations in resistant to airflow in ourselves at one part per million SO_2. It would not be a fatuous extrapolation to say that the effects of the 1952 episode and the others may well have been due to sulphur dioxide aided by whatever other irritants there were present.

In the animal model, it has been demonstrated quite convincingly that there is so-called synergism between SO_2 and some particles. Synergism is a much misused word and really indicates multiplicative effects and I am not sure

that some of the results reported are merely additive; but it would seem that the addition of an aerosol of common salt or some particulate matter to SO_2 in the female animal experiments can do mischief, but it has not been reported in man. We have repeatedly failed to show synergistic effects. Sulphate is a common topic and we have gassed ourselves with many sulphates and sulphites and we have no effects with any "realistic" concentrations.

Epidemiologically, of course, the news is wonderful; we can no longer discern any changes in morbidity or mortality, nor even in the diary surveys in which we were looking closely at particularly susceptible people. Any effect of pollution is now lost in background noise; other stresses, such as infection, bread strikes maybe, smoking overwhelmingly, cold certainly, heat - they are all producing background noise higher than the signal that we are looking for.

Regarding chronic effects; we have found no evidence whatsoever that harm arises from constant exposure to low concentrations of sulphur dioxide and particulates; once again all our work shows the overwhelming effect of smoking. In children, it looks as though past exposure to relatively massive concentrations could have favoured the development of lower respiratory tract infections and set the scene for liability to chronic bronchitis later. There remains a very important topic for research on the effects of SO_2 and that is the relevance of the sulphite radical. Some work at present would seem to indicate that unionised sulphite (I didn't know it existed) can penetrate cell membranes more rapidly than ionised sulphite, and we are striving to find out why sulphur dioxide and sulphite would appear to be so effectibe as bronchio-constricting agents.

Carbon monoxide is another pollutant which was selected not because there is epidemiological evidence of it doing any harm but because it seemed reasonable to expect that it might because of what we know about its action. It blocks transport of oxygen to the cells and the most obvious thing to do, first of all, was to look at its effect on the brain and perception, because the brain is the organ most sensitive to oxygen lack. We found that even gassing ourselves 10% there was no evidence of any changes in perception or performance. If in the tests we had used a quarter of a pint of bitter or any mild sedative, these would have given positive results. That does not mean we like carbon monoxide; after bicycling or walking in the streets, and spending hours in traffic jams, we have done over 250 blood samples, mostly on myself, and I have never had 3% saturation in my blood with carbon monoxide, whereas it would be rare to find a smoker with less than 4% or 6%, and figures of over 10% are quite common. Again, I say, this does not mean we approve of CO. We are now paying attention to its effect on the cardiovascular system and on the respiratory system because there are people who can't tolerate any more oxygen lack and obviously this might mean that CO could be considered almost a no threshold pollutant. If you found somebody in such bad health that he could not tolerate any further deficiency of oxygen then the addition of some carbon monoxide could implicitly be harmful. But we all have some carbon monoxide in our blood derived from the breakdown of our blood pigments.

Tom Iddison told me this morning that in an excellent book on cycling there was the outrageous statement that cycling in polluted air was equivalent to smoking two packets of cigarettes a day. This is not only arrant nonsense, it's wicked nonsense, inasmuch as it might stop people cycling in towns and encourage them as an alternative to have two packs a day. I can give you actuarial evidence about the effects of two packs a day; fortunately in our cycling in towns we have no evidence of harm.

Now, to consider oxides of nitrogen: I look for some reason for studying them, and the more I look the more I wonder why these particular pollutants have been selected, because there are neither epidemiological nor experimental data to incriminate them. I suppose they have gained attention because they took part in the formation of photo-chemical so-called "smog", and very properly inasmuch as that affects amenity. This does not mean that I suggest that we ought not to investigate oxides of nitrogen, and indeed we are doing so. NO is present in mainstream cigarette smoke in concentrations of 1000 parts per million. We have never measured over 1 part per million in the streets. Indoor pollution by cooking of course is receiving increased attention, therefore we have got to look at NO and NO_2.

Another group of pollutants selected for consideration are chlorinated hydrocarbons. But these must be defined. TCDD (Tetra-Chlor-Dibenzo Dioxine) as released in Seveso is one of the most intriguing and toxic of chemicals; DDT is interesting, must we also look at mothballs, Rentokil, Chloroform and carbon tetrachloride in the envirnment? The current concern about lead may have caused more distress and alarm than almost any pollutant in our history. I am particularly distressed about the failure or the refusal of some people to look at results which are comforting and which cut across their contention that the major source of lead in our bodies comes from the air of street. There have been books written, there have been conferences held about the absorption of lead from water, food and air. But how many people have taken any notice of our findings in ourselves? It seems sensible to to bleed ourselves. The range of blood lead in my unit is from 6 microgrammes per hundred ml. to the highest of 23,. The upper limit of pediatric normal below which nodody at Great Ormond Street would consider a child to have any lead trouble is 35 milligrammes per 100 ml. We have examined the blood of 58 children of 10-11 years old at a Newham School in London and the mean blood lead was 9.2, the maximum was 16. We've increased our observations right up the school, the mean (including some of the staff, now about 170 people,) has I think gone up to 12 with a maximum of 22. They breathe just like us; I think that it would be sensible to take these results as an indication that at least the air is not the major source of lead though of course, we would be happy if it were not there.

At my last appearance as your President of the NSCA, A.J. Clarke, my good friend, asked me what my priorities were. I ducked the question then, on the excuse that I wasn't going to give away any ammunition that I was saving for Harrogate. The truth was that I had not got a clue then and I still don't know. I am saddened by failure of so may people to rejoice in the improvement which we've seen since I first appeared at the Southport Conference in 1956 when you could hardly see across the room for tobacco smoke and other types of pollution. But I would say that it is important to look at the

fundamental mechanisms by which sulphur dioxide does what it does; it is not through alterations of PH on bronchoreceptors, we ought to elucidate the fundamental mechanism by which SO_2 produces its effect.
The other thing that I would like is to have time, away from committees, to do fundamental research instead of having to satisfy anybody who plucks out one of the 95 elements and decides it might do you harm. Toxicity is a word which is abused by many people. Fluorides and TCDD for example are both toxic. Fluorides, as you know, are toxic to cattle but the mechanism of that toxicity is so different from the mechanism of toxicity of the other compounds: it gives cows osteo-arthritis and as the cow is a bovine mower, if it has lame knees and can't cover the ground it won't eat enough; the osteo-arthritis also effects the temporo-mandibular joint and as you know ruminants chew lateracy instead of the way we do; So, if the cows cannot chew properly they get bad mechanical apposition of the teeth which wear down so that the pulp of the teeth are exposed and it is painful for it to eat as well as being difficult to get to food. It starves to death. Well, that toxicity is wholely different from the micrograms per kilogram toxicity of TCDD. We must study mechanisms with the toxicologist rather than flogging dead horses.

About mesothelioma and asbestos - the last time I talked to the Society about asbestos I was thinking how odd it was that the substitution of an iron molecule for a magnesium molecule in the cryocidolite fibre as against the chrysotile fibre would enable it to produce this very rare and fatal tumor mesothelioma. As times go on it would seem to be that it is the physical dimension of the fibre which is important, and not necessarily the chemistry (though the chemistry determines the size of the fibre). These are the kind of things we want to study. But we must be grateful for the present improvement.

I am increasingly intrigued with concern over stress and amenity and therefore in more ways than one that I would hand over to Professor Mellanby and the land fit for lichens to live in.

NATIONAL SOCIETY FOR CLEAN AIR

44th CLEAN AIR CONFERENCE

SEPTEMBER 19 - 22, 1977

HARROGATE

THE FIFTH REPORT OF THE ROYAL COMMISSION ON ENVIRONMENTAL POLLUTION - COMMENTS BY THE CBI

A.I. Biggs
Deputy Director, Company Affairs,
Confederation of British Industry

136 North Street
Brighton BN1 1RG
England

1. Introduction

Mr. Moorhouse's paper, which is printed, deals essentially with that which has been achieved by industry and what may be done in the future. This supplementary paper deals with the proposals in the Fifth Report of the Royal Commission on Environmental Pollution and the response of industry to some of the recommendations in this report. In particular, these will include the views of industry on the formation of the unified pollution inspectorate, more commonly referred to as Her Majesty's Pollution Inspectorate (HMPI) planning and pollution and the control of air pollution.

There is one point I would wish to make before dealing with the Royal Commission's Report; I refer to Government's industrial strategy. This is supported by Government, the TUC and the CBI. Its success is critical to the future well being of this country which means all of us. Industry and commerce are the principal wealth producers; the providers of the financial resources on which improvements in our standard of living must depend. The Secretary of State for the Environment has underlined, in both NEDC and in a circular letter, the importance of constructive environmental and planning policies as part of the industrial strategy. I believe that future clean air policy, and its implementation, should be considered as an integral part of this industrial strategy, and not in isolation.

2. Her Majesty's Pollution Inspectorate (HMPI)

The recommendations of the Royal Commission on HMPI may be summarised as follows:-

the establishment of a new unified inspectorate to ensure an integrated approach to difficult industrial waste problems at source where these affect air, water or land;

the Inspectorate will be centrally administered and highly qualified technically and would absorb the existing staff and responsibilities of the Alkali Inspectorate;

consideration to be given to the elimination, reduction and the re-cycling of wastes whilst establishing a close liaison with water authorities and waste disposal authorities;

the new Inspectorate should report to a central pollution policy body within the Department of the Environment.

These recommendations are inseparable from the considerations of the functions and responsibilities of the Alkali Inspectorate. The CBI's general attitude on this subject has been expressed formally and consistently over a considerable period of time. The CBI first raised this matter in its evidence to the Robens Committee on "Safety and Health at Work".

It was felt then, and is still felt now, that the Robens Committee failed to recognise the primary functions of the Alkali and Clean Air Inspectorate in its responsibility for industrial emissions to the atmosphere and to the Secretary of State for the Environment in this context. The Inspectorate's work applies to the general environment and is closely related to industrial planning; a matter for which the Secretary of State for the Environment is responsible.

The CBI is well aware of the technical expertise already available within the Alkali and Clean Air Inspectorate, and is satisfied that the Inspectorate can provide a nucleus for HMPI, both centrally and regionally when the central inspectorate is created.

The CBI's attitude to the Royal Commission recommendations on HMPI may be summarised as follows:

i. The Alkali Inspectorate should be returned to the Department of the Environment forthwith, irrespective of whether or not the new central pollution inspectorate is established.

ii. Any such new inspectorate must be directly responsible to the Secretary of State for the Environment.

iii. If established the new central inspectorate must have advisory, but not executive, functions.

iv. It should be small but technically highly competent.

v. The effectiveness of any new system might usefully be reviewed after a reasonable period of time.

In the CBI's view, the Inspectorate could advise the Secretary of State on the technical aspects of protection of the environment, both nationally and internationally.

3. Planning and Pollution Controls

The recommendation appended to the Fifth Report of the Royal Commission may be summarised as follows:

pollution policies should be embodied in structure and local plans by local authorities:

consideration should be given to the establishment of "buffer zones" for some industrial establishments;

planning authorities should be required to consult the Alkali Inspectorate during the preliminary discussion stages;

local authorities are already required to take account of the need to improve the environment, a more specific requirement should be laid down in respect of pollution;

planning authorities should be able to require those proposing major developments of special significance to assess total pollution effects with such assistance as they may need from the planning authority and other specialist organisations;

planning authorities should not duplicate the work of the Alkali Inspectorate by attempting to control emissions through the imposition of planning conditions; their sanction is to revise planning permission;

the Government should investigate the possibility of relating planning permission to a change of use of land;

publication of guidelines on pollution issues should be undertaken by the Government for the use of planning authorities.

Looking at these recommendations from an industrial stand-point, the CBI took the line that the main need was for planning authorities to achieve an acceptable relationship between the competing uses for land, bearing in mind at all times the real economic needs of the country and the development of the industrial strategy.

The CBI recommended that local planning authorities should have regard to the possible effects of pollution, not only in relation to industrial application, but in connection also with proposals for residential and other kinds of development near industrial buildings. Industry would welcome the introduction of "buffer zones" where necessary.

At the same time, industry is very much aware of the problem that has been caused by inadequate planning in the past, whereby established industrial plants have become encircled by residential development. This should not, however, lead to the inhibition of further development of factories, more particularly when the proposal is for development in the same use class. Furthermore, any revocation of permission or service for a discontinuance of any use must continue to attract compensation.

Industry is generally in complete accord with the view of the Royal Commission that planning authorities throughout the country should adopt a common uniform approach to environmental problems associated with a particular type of development. To this end they will need to seek advice from pollution authorities, both on individual applications and on development plans. It is industry's hope that consultations of this kind may help to reduce the time taken to reach planning decisions.

Industry has always urged that planning conditions should not be used in order to impose pollution control obligations. Such practices can, and do, lead to unnecessary duplication and delays. Industry has therefore consistently supported the statement made by the then Minister of Housing and Local Government as long ago as 1957 that planning should not be used as the ultimate weapon for dealing with matters that can be controlled by other powers. The CBI was pleased to see that the Royal Commission reiterates this view.

Industry is fully aware of the need to assess environmental effects of proposed major development as far as is possible. A measure of industry's concern in this matter is the practice of entering into early and continuous dialogue with the planning and pollution control authorities at the earliest possible stage. In many instances, at the most elementary pre-planning stage, by adopting this approach industry has been able to ensure compliance with environmental controls and to cut down the time needed to satisfy the authorities on such points when a formal planning application is lodged.

Bearing in mind the successful record of these early and full consultations, industry is completely opposed to the introduction of any formal or statutory environmental impact analysis system into the United Kingdom. Such rigid procedures would only result in considerable extra cost and unnecessary delay in the planning permission with undue emphasis on the environment at the expense of other matters, such as improvements of benefit to the national economy which should be given equal weight when a planning decision is being made. At this time it is considered that present procedure is based on fair democratic principles which have always contributed to the effective freedom given to developers and authorities alike.

The 1972 revision of the Use Classes Order was accomplished with the help of industry and the industrial classes were regrouped to take account of modern industrial processes. The CBI feels that recent developments and technological advance do not warrant a further revocation at this time. We therefore do not agree with the recommendation of the Royal Commission that a further study of industrial classes should be carried out. The revised Town and Country Planning (Use Classes) Order issued in 1972 in fact embodies environmental considerations in as much as, for example, those processes which give rise to grit and dust are grouped in a separate class from those liable to give rise to offensive odours. Similarly, industry is opposed to the Commission's tentative suggestion that planning permission for development in areas of high pollution should be limited to a particular person or company. Such a restriction would, in effect, turn each permission into a personal permission.

Not only would this be contrary to general Government policy, as set out in DoE Circular 5/68, that permission should only, in very special circumstances, be given to one person or company, but also it would lessen the owner's or leaseholder's chance of disposing of his interest should he desire to do so, hence disrupting the market in industrial property.

It is most unlikely that very special circumstances justifying personal permission will arise in the environmental field where adequate technical controls already exist. As for the possibility of revocation of permission or service of a discontinuance order with any liability for payment of compensation, it is better that existing compensation provisions and principles should remain unaltered. Planning procedures include adequate provision for the requisition of further deals even on an outline application if the planning authority considers this to be necessary. Should a permission be revoked, normal compensation procedures must continue.

In conclusion, I would again like to emphasise industry's belief in the importance of full consultation with the controlling authorities on both planning and pollution matters. Only by the adoption of this procedure is it possible to establish true co-operation and keep delays in obtaining consent, and hence in future industrial development, to an acceptable minimum.

4. Air Pollution Control

The recommendations appended to the Royal Commission's Fifth Report may be summarised as follows:

the Government should assist local authorities by issuing guidelines drawn up to assist them in domestic smoke control;

decisions concerned with smoke control should be made by local authorities after furnishing suitable explanations as to the needs for such control;

decisions concerned with the scheduling or de-scheduling of work should be continued to be taken by the Secretary of State for the Environment, but only after wide consultation,

comprehensive new legislation should be enacted to cover all aspects of industrial air pollution. This should include the best practicable means (bpm) concept and the power to limit the rate of, or ban the discharge of, a specified pollutant;

the need for a wider participation in the determination of the bpm philosophy exists, where the final decision should remain with the Alkali Inspectorate;

greater care should be paid to air quality by the Government in establishing air quality guidelines for certain pollutants. Application for registration or re-registration of works should be made through the local authorities to the Alkali Inspectorate. Registration will take the form of a consent which will be renewable at regular intervals;

local authorities should issue consents for the more difficult works under their control; such consent conditions could be amended or waived by a district Alkali Inspector in the light of unusual local circumstances;

recommendations in the respect of registers, consent inspection, breaches of consent and complaints;

data concerned with the emissions should be made public to the local authorities;

government should publicly pledge itself to the spirit of any new legislation and consult the relevant pollution control officers on the best means of combatting air pollution.

The CBI is aware of the importance of air quality resulting from domestic smoke control procedures and acknowledges that some of the Royal Commission's recommendations could warrant further investigation to possibly effect even greater improvements.

With respect to the scheduling and de-scheduling of works, the CBI agrees with the Royal Commissions's conclusion that the closest possible co-operation between the central inspectorate and the local authorities staff is essential if the best use is to be made of available technical expertise. The processes under consideration are most involved and complex. There is considerable merit, therefore, in the scheduling and de-scheduling procedures to be made by means of a statutory regulation.

The CBI strongly supports the return of the Alkali Inspectorate to the Department of the Environment for reasons given in earlier parts of this paper. The CBI does not support the Royal Commission's recommendation for further new legislation, although there may be merit in consolidating the legislative framework, within which the Alkali Inspectorate operates, if this Inspectorate is to be returned to DoE control.

The UK's air pollution control is comprehensive and amongst the most advanced in the world. Furthermore, the UK has a first-class record for the promotion of improvements in air quality. We believe that the most effective course is the further implementation of existing legislative powers in a gradual and progressive manner.

The Confederation has always endorsed the best practicable means approach to the abatement of air pollution. This concept has been a major contribution to the success which has been achieved by air pollution controls in this country. We believe that these will continue to make a significant contribution. The CBI strongly supports the Royal Commission's recommendations on this point, both in terms of the success in the past and the acknowledgement of the economic constraints that have to be closely examined in connection with this technique. We can see no real conflict between bpm and the determination of air quality objectives.

The Confederation believes that the recommendations concerned with local authority registration and consents should be actively discouraged. They could result in the Alkali Inspectorate becoming removed from the "active" scene. There should be direct links, particularly at the planning and development stages, between industrial companies and the effective controlling authorities. For the same reasons industry has reservations about the recommendation that suitably qualified Environmental Health Officers should be allowed to deputise for Alkali Inspectors. The CBI contend that it would be preferable to recruit and train additional Alkali Inspectors as and when necessary. As regards the publication of breaches of consent conditions, the CBI believes that this subject is adequately covered by the Control Pollution Act 1974, Part IV, which provides for the publication of information relating to emissions from both scheduled and unscheduled premises. Additional powers would seem to be unnecessary and could lead to a confused situation.

Finally, I should like to stress the relationship between the environment, energy production, research and technology and future industrial development. These are very closely interlinked and any policy on the abatement of air pollution which is narrowly conceived could only be counter-productive and not in the best national interest.

To summarise, the CBI, with some reservations, accepts the main recommendations of the Fifth Report of the Royal Commission on Environmental Pollution.

NATIONAL SOCIETY FOR CLEAN AIR

44th CLEAN AIR CONFERENCE

SEPTEMBER 19 - 22, 1977

HARROGATE

EXPOSURE OF THE PUBLIC TO RADIOACTIVE DISCHARGES FROM THE NUCLEAR FUEL CYCLE

Miss Pamela M. Bryant
Senior Environmental Adviser
National Radiological Protection Board

and

Miss Frances E. Taylor
Senior Scientific Officer in Environmental Studies
Group, National Radiological Protection Board

136 North Street
Brighton BN1 1RG
England

1. INTRODUCTION

There is now substantial public debate on the effect on the environment on the public and on society itself, of present and proposed operations of the nuclear fuel cycle. The year 1977 is noteworthy for the Public Inquiry into the proposed Oxide Reprocessing Plant at Windscale. It is expected that all the relevant safety, environmental and planning considerations will be fully examined. It was in 1967 that Dr. E.F. Schumacher gave the Des Voeux Memorial Lecture on "Clean air and future energy"(1) at the Conference of the National Society for Clean Air at Blackpool. In this lecture he raised nuclear issues evoking public interest today. Solutions for some of these, for example methods of disposal of high activity fission product waste, are currently under investigation in the United Kingdom and elsewhere. The scope of this paper is limited, however, to a review of exposure of the public to radioactive discharges to the environment from routine operation of the nuclear fuel cycle.

This paper draws on a review presented at the "International Symposium on the Management of Wastes from the LWR Fuel Cycle" held at Denver in 1976(2). It summarises the methodology used for assessing the radiation exposure of the public arising from the discharge of radioactive effluents and draws attention to its limitations. It reviews the levels of radiation exposure resulting from the operation of thermal reactor fuel cycle installations in the United Kingdom in recent years in relation to the relevant primary radiological protection standards. The paper refers to a recent assessment of the radiological significance of long-lived radionuclides discharged from nuclear installations. It concludes with a summary of other sources of radiation exposure of the public and a comparison of the magnitude of these exposures with those from radioactive discharges from nuclear fuel cycle installations. Reference should be made to the paper entitled "Radioactivity and the nuclear fuel cycle", presented at this Conference by Dr. R.H. Clarke(3), for information on sources of effluents giving rise to exposure of the public; reference should be made to the paper by Mr. J. Beighton for information on "The control of airborne radioactive emissions from nuclear power stations in the United Kingdom"(4).

The literature does not provide a global and detailed review of radiation doses actually received by the public from nuclear fuel cycle installations. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) attempted such a review, and its findings are given in its 1972 report(5). The Committee stated that the doses incurred by the population can be assessed either by an adequate knowledge of the quantities discharged and of the transfer parameters involved or by means of a programme of environmental monitoring that is usually related to pathways selected as being of the greatest importance. The Committee commented that both approaches had serious shortcomings for the dose assessments it required. In the view of the Committee, calculations based on transfer models were subject to considerable uncertainty because of the complexity of the field conditions and because in many cases the simplified models available were unrealistic. Monitoring, on the other hand, was frequently geared to ensure compliance with accepted limits and therefore provided insufficient information on the very low doses that might be incurred by

members of the public. The Committee also commented that data on discharges were unavailable for some operating reactors and limited in scope for others, being mainly in the form of gross activity measurements and therefore unsuitable for the estimation of doses. As a consequence, the Committee's 1972 report included few data on doses; the same Committee is once again compiling available information and will report in 1977. Perhaps the most cogent of the UNSCEAR comments is that many environmental monitoring programmes, certainly in the past, have not been designed for dose estimation purposes; it will be interesting to see whether there has been a substantial improvement in this direction over the last few years.

2. PRIMARY AND DERIVED RADIOLOGICAL PROTECTION STANDARDS AND THE METHODOLOGY OF DOSE ASSESSMENT

The objectives of radiological protection are to prevent acute radiation effects, which usually manifest themselves within a few weeks of the exposure, and to limit the risk of late effects to an acceptable level. Late effects, which may have a latent period of up to tens of years, include leukaemia and other malignant diseases in exposed individuals (somatic effects) and hereditary defects manifested in the descendants of the exposed individuals (hereditary or "genetic" effects). Primary radiological protection standards, in particular those recommended by the International Commission on Radiological Protection (ICRP)[6], are expressed primarily in terms of radiation dose limits to individuals. When whole populations or large sections of populations are exposed, however, it becomes necessary to consider not only the magnitude of individual risks but also the numbers of persons exposed. Even when individual exposures are sufficiently low for the risk to the individual to be acceptably small, the total number of somatic and genetic effects in a population under consideration may justify the effort required to achieve further limitation of exposure. The dose limits are part, therefore, of a wider system of dose limitation aimed at keeping radiation doses down to levels that (1) can be justified from the benefits from the procedures giving rise to the doses, and (2) are as far below the dose limits as can reasonably be achieved[7]. The processes involved in attaining the latter objective are now commonly called "optimisation". The Commission has reconsidered the fundamental principles upon which appropriate radiological protection measures can be based and has recently published its views[8].

The quantity used in this paper for radiation dose is "dose equivalent". The term "dose equivalent" means the product of the absorbed dose (ie, energy absorbed per gram of tissue) and appropriate factors to account for differences in biological effectiveness owing to the quality of radiation and its spatial distribution in the body. The unit of dose equivalent is the "rem". One millirem (mrem) equals 0.001 rem. Because of the lack of knowledge of the nature of the dose-effect relationship in the induction of malignancies in man - particularly at those dose levels which are relevant in radiological protection - the Commission sees no practical alternative, for the purposes of radiological protection, to assuming a linear relationship between dose and its effect. The Commission is satisfied that this assumption is unlikely to lead to the underestimation of risks. A guide to the upper limit of potential health effects is given

by the quantity "collective dose equivalent". This is the product of the average individual dose equivalent and the number of individuals in the population. The unit of collective dose equivalent is the "man-rem".

Doses received by the public from discharges of radioactive effluents to the environment are almost invariably too small to be measured directly and must be deduced from radionuclide discharge rates and/or levels of radiation dose rate or radioactivity in environmental materials; all these parameters may be determined either by measurement or calculation. It is convenient to make use of secondary protection standards expressed in terms of such levels and calculated in such a way that compliance with them ensures compliance with the primary standards. In the United Kingdom such secondary standards are called Derived Working Limits (DWLs); they afford a useful basis for the interpretation of the results of environmental monitoring programmes. Since primary standards relate to the individual and secondary standards usually relate to the environment, the relationship between the two types of standard can only be established with the aid of some model representing the relationship between the individual and his environment. Most models are compromises between the need for accuracy and the need for simplification and generalisation. Greater accuracy is needed when models are used in circumstances where the exposure of the public is at levels constituting substantial fractions of the relevant dose limit; in such circumstances environmental monitoring programmes would be an essential part of the dose estimation procedure.

The ICRP has recommended an annual Dose Limit of 500 mrem to the whole body as appropriate for an individual irradiated more or less uniformly either by a radiation source outside the body (external irradiation) or by radionuclides taken into the body (internal irradiation)[6,8]. In 1966, the ICRP recommended different Dose Limits for certain organs, for example, the thyroid gland, the skin and the gastro-intestinal tract (Table 1)[6]. The ICRP has introduced the concept of weighting factors for certain organs into its recent recommendations[8]; the National Radiological Protection Board is evaluating the implications of these recommendations.

3. RADIATION EXPOSURE TO EFFLUENTS FROM NUCLEAR FUEL CYCLE INSTALLATIONS IN THE UNITED KINGDOM

3.1 Fuel Fabrication and Enrichment

British Nuclear Fuels Limited (BNFL) discharges liquid effluents from the Springfields fuel manufacturing plant by pipeline to the tidal reaches of the River Ribble. The only radiological consequence of this waste results from the reconcentration of protoactinium-234m on muddy areas on either side of the river; although members of the public occasionally visit the mud-flats near the outfall, their annual dose equivalent has not exceeded 5 mrem[9-11]. The relevant annual Dose Limit is 500 mrem. BNFL discharges liquid effluents containing small amounts of uranium from the Capenhurst enrichment plant into a stream which eventually joins the River Mersey; the effluents are of no radiological significance. BNFL also discharges small quantities of natural and slightly enriched uranium in

effluents to atmosphere from the Springfields and Capenhurst plants; these effluents are similarly of no radiological significance.

3.2 Power Generation

The Central Electricity Generating Board (CEGB) and the South of Scotland Electricity Board (SSEB) have, until recently, operated "commercial" nuclear power stations solely of the type known as "Magnox"[3]. Most of these stations are sited on open coastlines or large tidal estuaries; the exception is the station at Trawsfynydd in Wales which is on the shore of a freshwater lake. The data in this paper refer only to these Magnox stations and not to the Advanced Gas-Cooled Reactor stations now being operated and commissioned in the United Kingdom[3].

Liquid Effluents

The Fisheries Radiobiological Laboratory (FRL) of the Ministry of Agriculture, Fisheries and Food (MAFF) publishes the results of its environmental pathway studies and routine environmental monitoring related to liquid effluents from nuclear power stations. The data in Table 2, drawn from recent reports[9-11], illustrate the radiological consequences of liquid effluents from Magnox stations; the major radioactive component (excluding tritium) in these discharges is radiocaesium (caesium-134 and caesium-137)[3]. The maximum annual dose equivalents to members of the public are very low except at Trawsfynydd where the higher doses reflect the lakeside siting of this station; the exposure pathway is consumption of trout from the lake. Exposure pathways for the other Magnox stations are external radiation from radioactivity on the shore and consumption of fish and shell fish. The tritium discharged from Magnox stations gives rise to public radiation exposure of no radiological significance.

Effluents Discharged to the Atmosphere

The major radioactive component of discharges to atmosphere from six Magnox stations with steel pressure vessels is argon-41; Clarke has cited approximate discharge rates[3]. The authors have calculated annual whole body dose equivalents at ground level in the open air (Table 3) using recent data from Clarke[12-14]. The public has access to certain places along boundary fences around Magnox stations at only 100 metres from the reactors; members of the public are unlikely to spend a significant portion of their time, however, in the open air at any distance less than 400 metres from the reactors where the dose equivalent rates are considerably lower than at 100 m. The radiation exposure actually incurred by individuals living at any distance cited in Table 3 would be lower than indicated because of the screening provided by houses. Clarke[13] used a screening factor of 0.63 in his estimates of annual collective dose equivalents to the United Kingdom population from argon-41 discharges (Table 3). The total collective dose equivalent to the population from these stations is about 160 man-rem, the largest individual contributor being the Magnox ("A") station at Hinkley Point.

3.3 Fuel Reprocessing

BNFL reprocesses commercial reactor fuel at the Windscale Works situated on the Cumbrian coast of the Irish Sea (Fig. 1). The reprocessing plant and the associated facilities are the chief contributors to discharges from the Works.

Liquid Effluents

The FRL publishes the results of its extensive environmental pathway studies and routine environmental monitoring related to liquid effluents discharged by the Works by pipeline to the sea. Table 4 summarises radiation exposure of members of the public in recent years[9-11,15,16]. The data show that the relative importance of pathways changes with time; the reasons include changes in the quantity and composition of radioactivity discharged, in the environment and in the habits of the population exposed.

The most important exposure pathway until 1972 was consumption by people in South Wales of the foodstuff "laverbread" made from the edible seaweed "porphyra". Some of the weed consumed was harvested along the Cumbrian coast. Harvesting first declined near the pipeline[9]; in 1974 it ceased altogether along the Cumbrian coast due to the retirement of the remaining harvester[10]. The FRL has continued to sample and analyse the weed as an indicator of contamination levels and because a resumption of its collection cannot be ruled out.

Discharges of caesium-137 and the associated caesium-134 were much higher during 1974 - 1976 than previously[17]. The most significant exposure pathway is now the consumption of fish and crustacea contaminated with these radionuclides. The FRL has conducted special surveys of these foodstuffs in the immediate vicinity of Windscale and from commercial landings at Whitehaven from boats operating throughout the Irish Sea. Table 4 shows the estimated radiation exposure of local fishermen at St. Bees, Braystones and Ravenglass and of consumers of commercially-landed fish at Whitehaven. The northeast Atlantic and the North Sea also contain radiocaesium from Windscale at low concentrations. The FRL used annual fish landing statistics and measured concentrations in fish to estimate annual collective dose equivalents to the United Kingdom population (Table 4). These estimates include small contributions from radiocaesium discharged from coastally-sited Magnox power stations and the relatively small scale reprocessing operations of the UK Atomic Energy Authority at Dounreay in Scotland.

The reconcentration of some gamma-emitting nuclides, particularly zirconium-95/niobium-95, ruthenium-106 and caesium-137, on marine sediments provides an external exposure pathway for a relatively small number of people. The FRL regularly monitors gamma radiation dose rates on the shore at distances from Windscale ranging from Walney in the South to Maryport in the North (Fig. 1). The dose rates are highest where mud collects, notably in the Ravenglass Estuary. Members of the public use this estuary for bait digging, salmon trapping and boat repairing. Table 4 shows estimates of annual dose equivalents to the most highly exposed individual, allowing for an occupancy factor and dose equivalent rate variations. Most of the

Cumbrian coastline consists of coarse sand where dose equivalent rates in general are very much lower than in the Ravenglass Estuary.

The FRL also has a continuing environmental research programme related to discharges of transuranics, notably the alpha-emitting radionuclides plutonium-239, plutonium-240 and americium-241, to the Irish Sea from the Windscale Works. Hetherington et al have recently reviewed some of this work[18-20]. They concluded that about 96% of the plutonium discharged is quickly removed from the sea on to sediments and that there has been no detectable remobilisation over periods of up to 20 years. The remaining 4% is dispersed in coastal waters in a similar manner to radiocaesium. Exposure pathways include consumption of contaminated marine organisms, for example, the seaweed "porphyra", fish and molluscs. Ingested transuranics accumulate in bone and exposure of the individual continues at a decreasing rate even if ingestion of the contaminated foodstuff ceases. Published estimates of the exposure to bone of consumers of foodstuffs contaminated with transuranics are often upper limits relating to an equilibrium situation. Although discharges of alpha-activity have been roughly constant over the last few years, there is no reason to suppose that an equilibrium level of these nuclides has been reached in the bone of consumers. Another potential exposure pathway presently under investigation is that of inhalation of wind-blown dried sedimentary deposits contaminated with transuranics.

Effluents Discharged to the Atmosphere

BNFL discharges very small quantities of radioactive particulates from the Windscale Works to atmosphere (Table 3[3]). The main interest with regard to public radiation exposure, however, lies in discharges of gaseous radionuclides with long half-lives, particularly krypton-85, tritium, iodine-129 and carbon-14, which contribute to global as well as local and first-pass doses. A report prepared by the National Radiological Protection Board (the "Board"), under contract to the Health Protection Directorate of the Commission of the European Communities, gives estimates of the radiological significance for the population of the European Community of discharges of these radionuclides to the environment by the nuclear power industry to the end of the century[21]. Table 5 gives estimates, using models in the report, of the exposure of the United Kingdom population during the period 1973 - 1976 from discharges of these four nuclides from the Windscale Works (Table 3[3]). The values in Table 5 do not include the predicted exposure from the power programme in the rest of the world because no other country, except France, with a substantial programme of nuclear power generation has been operating a full-scale reprocessing programme for commercial fuel. The radiation exposures to the end of the century, predicted in the report, depend on many assumptions eg, that irradiated fuel will be reprocessed at the rate at which it is produced and present waste management practices will continue unchanged. The predicted exposures are now almost certainly overestimates because of recent reductions in the predicted size of power programmes, the expected shortage of reprocessing capacity and changes in waste management practices leading to reduction of predicted discharges, particularly in the United States following the recent recommendations of the Environmental Protection Agency[22].

The Ocean Disposal of Packaged Solid Waste

The management of solid radioactive wastes is outside the scope of this paper. However, the topic of exposure resulting from certain disposals is relevant. The United Kingdom and some other European countries dispose of packaged solid radioactive waste of low activity in the North-east Atlantic at a depth of about 4000 metres. The packages will eventually disintegrate and radioactivity will be dispersed. Webb and Grimwood have discussed potential routes of exposure of man from this type of disposal and estimated the relationship between the rate of disposal and radiation exposure[23]. The doses to man from the disposals in recent years are trivial and no radioactivity attributable to these operations has been detected in surface waters in disposal areas.

4. THE SIGNIFICANCE OF EXPOSURE OF THE PUBLIC

The Board periodically reviews the radiation exposure of the UK public from all sources and published a report in 1974[24]. A further review is in progress. Table 6 illustrates the exposure of the UK population resulting from discharges of radionuclides from nuclear fuel cycle installations compared with that from other sources. The values given are annual gonad dose equivalents averaged over the whole UK population of about 55 million people, although only a section of the population may be exposed to a given source, for example fewer than 100,000 people are exposed occupationally. The authors calculated the value for irradiation by argon-41 from an annual collective dose equivalent of about 200 man-rem, comprising 157 man-rem from Magnox reactors with steel pressure vessels (Table 3) with a smaller contribution from other reactors in the UK, and that for irradiation by radiocaesium from an annual collective dose equivalent of 12,000 man-rem in 1976 (Table 4). The authors calculated the value for the other radionuclides to atmosphere from an annual collective dose equivalent of 137 man-rem, which is the sum of 7 and 80 man-rem to the gonads from krypton-85 and carbon-14 respectively and 50 man-rem to the whole body, including the gonads, from tritium in the body (Table 5). The authors have quoted values from reference 24 for the other sources of irradiation.

The total gonad dose equivalent from discharges of radionuclides from nuclear fuel cycle installations in the UK was 0.23 mrem in 1976, when the contribution from radiocaesium was higher than in previous years, compared with 14 mrem from medical irradiation which is by far the biggest single addition to natural background radiation (Table 6). The contribution to the annual gonad dose equivalent from medical irradiation is weighted to take into account the future child-bearing potential of the individual concerned (the contribution being called the "genetically-significant" dose equivalent); diagnostic radiology contributes the largest proportion of the exposure from medical irradiation. The annual dose equivalent from natural background averages 97 mrem, but some individuals are exposed to two to three times this level because the external radiation from radionuclides in rocks, buildings etc. varies widely over the country. Other components of natural background radiation are cosmic rays and internal radiation from radionuclides ingested in food. The dose equivalent of 2 mrem from fallout is due mainly to radionuclides deposited on the ground after the intensive period of nuclear weapons tests in the 1960s; it is

continuing to decrease slowly. The average dose equivalent from "miscellaneous sources" was estimated in 1974 to be about 0.7 mrem. Miscellaneous sources include consumer products such as radioluminous watches and artificially enhanced levels of natural radiation; an example of the latter is the increased exposure to cosmic radiation during journeys in aircraft. The gonad dose equivalent of 0.6 mrem from occupational exposure consists of approximately equal contributions from workers in the nuclear industry in general, including nuclear research establishments, and workers in non-nuclear industry and medicine. Thus the average exposure of the population, summing that to occupational workers and members of the public, from the nuclear industry is approximately equal to exposure of the public from miscellaneous sources.

REFERENCES

1. E.F. Schumacher, Clean Air and Future Energy, Des Voeux Memorial Lecture presented at the Annual Conference of the National Society for Clean Air, 1967.

2. F. Morley and Pamela M. Bryant, Radiation Exposures to Man from Releases of Radioactive Effluents, page 489, Proceedings of the International Symposium on the Management of Wastes from the LWR Fuel Cycle, Denver, Colorado, CONF-76-0701, 1976.

3. R.H. Clarke, Radioactivity and the nuclear fuel cycle, This Conference

4. J. Beighton, The control of airborne radioactive emissions from nuclear power stations in the UK, This Conference.

5. United Nations Scientific Committee on the Effects of Atomic Radiation, Ionising Radiation Levels and Effects, United Nations, New York, 1972.

6. Recommendations of the International Commission on Radiological Protection, ICRP Publication 9, Pergamon Press, Oxford 1966.

7. Recommendations of the International Commission on Radiological Protection, Implications of Commission Recommendations that Doses be kept as Low as Readily Achievable, a Report of ICRP Committee 4, ICRP Publication 22, Pergamon Press, Oxford, 1973.

8. Recommendations of the International Commission on Radiological Protection, ICRP Publication 26, Pergamon Press, Oxford, 1977.

9. N.T. Mitchell, Radioactivity in Surface and Coastal Waters of the British Isles, 1972 - 1973, Technical Report, FRL 10, MAFF Fisheries Radiobiological Laboratory, Lowestoft, 1975.

10. J.A. Hetherington, Radioactivity in Surface and Coastal Waters of the British Isles, 1974, Technical Report, FRL 11, MAFF Fisheries Radiobiological Laboratory, Lowestoft, 1976.

11. N.T. Mitchell, Radioactivity in Surface and Coastal Waters of the British Isles, 1975, Technical Report, FRL 12, MAFF Fisheries Radiobiological Laboratory, Lowestoft, 1977.

12. R.H. Clarke, Private communication, 1977.

13. R.H. Clarke and R. Wilson, Individual and Collective Doses due to Argon-41 based on measured discharge rates from CEGB reactors, page 577 in vol. 2 of Proceedings of Fourth International Conference of IRPA, Paris, 1977.

14. R.H. Clarke, The relationships between doses to human body organs and exposure in a cloud of gamma emitting nuclides, Central Electricity Generating Board Report, RD/N3863, 1976.

15. N.T. Mitchell, Radioactivity in Surface and Coastal Waters of the British Isles, 1976, Part 1 : The Irish Sea and its Environs, Technical Report, FRL 13, MAFF Fisheries Radiobiological Laboratory, Lowestoft, 1977.

16. A. Preston et al., Experience gained in applying the ICRP Critical Group Concept to the assessment of public radiation exposure in the control of liquid radioactive waste disposal, page 131, in the Proceedings of the IAEA Seminar on Population Dose Evaluation and Standards for Man and his Environment, Vienna, IAEA, 1974.

17. Mr. Bishop, Minister of State in the Ministry of Agriculture, Fisheries and Food, statement reported in ATOM page 248, June 1977.

18. J.A. Hetherington et al., Some investigations into the behaviour of plutonium in the marine environment, page 193 in Impacts of Nuclear Releases into the Aquatic Environment, International Atomic Energy Agency, Vienna, 1975.

19. J.A. Hetherington et al., Environmental and public health consequences of the controlled disposal of transuranic elements in the marine environment, page 139, in Transuranium Nuclides in the Environment, International Atomic Energy Agency, Vienna, 1975.

20. J.A. Hetherington, The behaviour of plutonium nuclides in the Irish Sea, page 81 in Radioisotopes in the Aquatic Environment : Models and Mechanisms, Proceedings of a Conference, Rochester, New York, 1975, Ann Arbor Science Publishers Inc., Ann Arbor, 1976.

21. G.N. Kelly et al., The Predicted Radiation Exposure of the Population of the European Community resulting from discharges of krypton-85, tritium, carbon-14 and iodine-129 from the nuclear power industry to the year 2000, Doc. V/2676/75, Commission of the European Communities, Luxembourg, 1975.

22. United States Environmental Protection Agency. 40 CFR 190 Environmental radiation protection requirements for normal operations of activities in the uranium fuel cycle, Final environmental statement, Washington, USEPA, EPA 520/4-76-016, 1976.

23. G.A.M. Webb and P.D. Grimwood, A Revised Oceanographic Model to Calculate the Limiting Capacity of the Ocean to Accept Radioactive Waste, National Radiological Protection Board, NRPB-R58, Her Majesty's Stationery Office, London, 1976.

24. G.A.M. Webb, Radiation Exposure of the Public - the Current Levels in the United Kingdom, National Radiological Protection Board, NRPB-R24, Her Majesty's Stationery Office, London, May 1974.

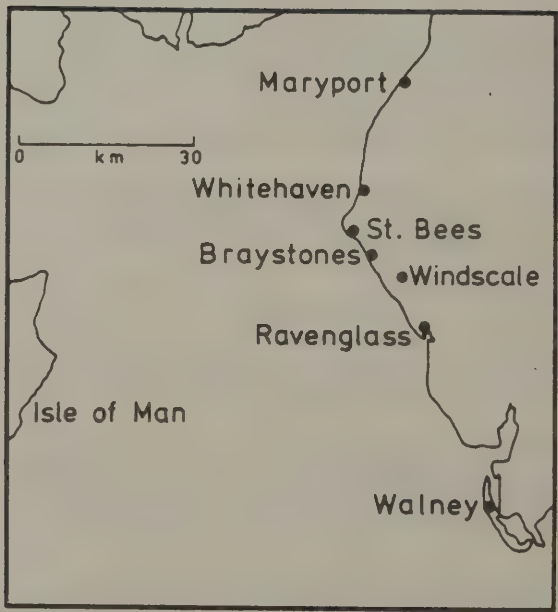


Figure 1 : The Cumbrian coast near the Windscale Works

TABLE 1

Dose Limits for members of the public recommended by the International Commission on Radiological Protection in 1966[6]

Organ or tissue	Annual Dose Limits for members of the public (mrem)
Whole body	500
Gonads and red bone-marrow	500
Skin, bone and thyroid gland a)	3000
Other single organs (including gastro-intestinal tract)	1500

a) For children up to 16 years of age the annual Dose Limit for the thyroid is 1500 mrem

TABLE 2

Estimates of public radiation exposure to liquid radioactive waste discharges from MAGNOX reactors in the United Kingdom, 1972 - 1975[a)]

Station	Exposure pathway	Maximum annual individual dose equivalent[b)] (mrem)		
		1972-1973	1974	1975
Berkeley/Oldbury	External dose	< 1.5	<0.5	<0.5
	Fish and shellfish	< 0.5	<0.5	<0.5
Bradwell	Oyster	0.5	0.5	0.4
Dungeness	External dose	< 0.5	<0.5	<0.5
	Fish	< 0.5	<0.5	<0.5
Hinkley Point	External dose	0.5	<0.5	<0.5
	Fish and shellfish	0.5	<0.5	<0.5
Sizewell	External dose	≪ 0.5	<0.5	<0.5
	Fish and shellfish	≪ 0.5	<0.5	<0.5
Trawsfynydd	Lake fish	30	35	40
Wylfa	External dose	≪ 0.5	<0.5	<0.5
	Fish and shellfish	≪ 0.5	<0.5	<0.5
Hunterston	External dose	< 0.5	<0.5	<0.5
	Fish and shellfish	< 0.5	<0.5	<0.5

a) Data from references 9-11

b) Relevant annual Dose Limit 500 mrem

TABLE 3

Estimates of public radiation exposure from argon-41 discharges from MAGNOX reactors with steel pressure vessels in the United Kingdom, 1974

Station	Annual individual dose equivalent[a] (mrem)			Annual collective dose equivalent[b] (man-rem)
	100 m	200 m	400 m	
Berkeley	10	5	3	22
Bradwell	8	4	2	17
Dungeness 'A'	13	7	3	19
Hinkley Point 'A'	37	19	10	52
Sizewell	24	12	6	18
Trawsfynydd	79	41	21	29

a) Relevant annual Dose Limit 500 mrem; values given take no account of the screening provided by houses

b) Values include allowance for screening by houses by a factor of 0.63

TABLE 4

Estimates of public radiation exposure from liquid radioactive waste discharges from BNFL Windscale Works, 1972 - 1976[a)]

Group/Pathway	Annual individual and collective dose equivalents			
	1972/73	1974	1975	1976
Porphyra pathway				
Gastro-intestinal tract dose to the critical group[b)]				
i) maximum dose	42 mrem	< 4 mrem	-[c)]	-[c)]
ii) mean dose	30 mrem	< 3 mrem	-[c)]	-[c)]
Fish pathway				
1. Local fishermen at St. Bees, Braystones, Ravenglass[d)]				
i) maximum dose	NA	70 mrem	170 mrem	220 mrem
ii) mean dose	NA	15 mrem	35 mrem	45 mrem
2. Consumers of commercially landed fish at Whitehaven[d)]				
i) maximum dose	42 mrem	70 mrem	170 mrem	238 mrem
ii) mean dose	15 mrem	25 mrem	60 mrem	85 mrem
3. Consumption by the UK population of fish caught in Irish Sea, North-West Scottish waters and North Sea.	1500 man-rem	4800 man-rem	8300 man-rem	12000 man-rem
External dose to fisherman in Ravenglass estuary[d)] maximum dose	35 mrem	35 mrem	45 mrem	40 mrem

NA not available; a) Data from references 9-11, 15, 16; b) Relevant annual Dose Limit 1500 mrem; c) Porphyra harvesting ceased in 1974; d) Relevant annual Dose Limit 500 mrem.

TABLE 5

Estimates of public radiation exposure from gaseous radioactive waste discharges from BNFL Windscale Works, 1973 - 1976.

Nuclide	Organ	Annual individual dose equivalent (mrem)		Annual collective dose equivalent (man-rem)
		1 km	5 km	
^{85}Kr	skin[a)]	2.5	0.9	1100
	gonad[b)]	0.04	0.009	7
^{3}H	whole body[b)]	0.04	0.02	50
^{129}I	thyroid[c)]	0.32	0.12	60
^{14}C	gonad[b)]	0.02	0.02	80
	whole body[b)]	0.03	0.03	130

a) Relevant annual Dose Limit 3000 mrem

b) Relevant annual Dose Limit 500 mrem

c) Relevant annual Dose Limit 1500 mrem (children up to 16 years) 3000 mrem (adults)

TABLE 6

Radiation exposure of the population in the United Kingdom

Exposure route	Annual gonad-dose equivalent (mrem)
Natural background [a]	97
Medical irradiation [a]	14 [b]
Fallout [a]	2
Miscellaneous sources [a]	0.7
Occupational exposure [a]	0.6
Argon-41 from reactors	0.004
Caesium-134 and caesium-137 in fish	0.22
Krypton-85, tritium and carbon-14	0.002

a) Data from reference 24

b) Genetically significant dose equivalent

Printed and published by
National Society for Clean Air, 136 North Street, Brighton BN1 1RG, England

P. G. SHARP

NATIONAL SOCIETY FOR CLEAN AIR

45TH ANNUAL CONFERENCE
2-5 OCTOBER 1978
BRIGHTON

CLEAN AIR – WAYS AND MEANS

PART 1
PRE-PRINTS OF PAPERS

136 NORTH STREET
BRIGHTON BN1 1RG ENGLAND

45th ANNUAL CONFERENCE
BRIGHTON, 2-5 October 1978

THE UK APPROACH TO THE CONTROL OF AIR POLLUTION - A EUROPEAN APPRAISAL

Dr. Erich Weber
Ministry of the Interior, Federal Republic of Germany

THE EUROPEAN APPROACH

P.J. Wilde
Department of the Environment

THE TASK OF THE LOCAL AUTHORITY, MONITORING, MEASUREMENT, COLLECTION AND DISSEMINATION OF INFORMATION

L.E. Robson
Environmental Health Department, City of Bristol

THE ROLE OF HM ALKALI AND CLEAN AIR INSPECTORATE

S.J. Hart
Formerly District Alkali Inspector, North West

THE TASKS OF INDUSTRY - MONITORING, MEASUREMENT, RESEARCH

H.I. Fuller
Esso Petroleum Co. Ltd.

THE NEED FOR EDUCATION - ARE WE DOING ENOUGH?

D.J. Lewis
Keep Britain Tidy Group

RESEARCH INTO METHODS OF INCREASING CHILDREN'S AWARENESS OF LITTER AND SENSE OF RESPONSIBILITY FOR THEIR ENVIRONMENT

Cherry Mares
Keep Britain Tidy Group

IS ENFORCEMENT OF EXISTING LEGILSATION ADEQUATE?

D.G.T. Williams
Emmanuel College, Cambridge

LOW ENERGY STRATEGIES FOR THE UK

Gerald Leach
International Institute for Environment and Development

ENERGY CONSERVATION IN INDUSTRY

Dr. N.J.D. Lucas
Imperial College of Science and Technology

THE ECONOMICS OF CLEAN AIR

Julian Lowe
University of Bath

AIR POLLUTION - THE COST OF ABATEMENT AND CONTROL

A.W.F. Maule
Environmental Health Department, City of Sheffield

NATIONAL SOCIETY FOR CLEAN AIR

45th ANNUAL CONFERENCE
2-5 OCTOBER 1978
BRIGHTON

THE UK APPROACH TO THE CONTROL OF AIR POLLUTION - A EUROPEAN APPRAISAL

by

Dr. Erich Weber,
Ministry of the Interior,
Federal Republic of Germany

136 North Street
Brighton BN1 1RG
England

I must admit that it is a difficult task for a foreigner to talk about the U.K. approach to the control of air pollution. At times I find it sometimes difficult to grasp what is the objective of air pollution control policy in my own country. Often, the language of politics and the complicated language of laws and ordinances is difficult to understand and to interpret - all the more so for a scientist who is used to thinking and talking in a different way. May I therefore first of all express my thanks to the organisers of this conference who had the courage to charge a foreigner with the task of commenting on goals and implementation of clean air policy in the United Kingdom from his point of view, i.e. from a European point of view.

Well, there is a specific term which has been spread all over the world. It is known everywhere that the policy of air pollution control in Great Britain is based on the principle of "best practicable means". I have, of course, also known this term for many years, and I have also talked about it or discussed it many times. However, it was only when I prepared this address that I learnt what are the full implications of the term "best practicable means". I think that outside the U.K. there is many an expert who is also not quite sure about the actual meaning of "best practicable means".

In spring this year when at the request of the National Society for Clean Air I accepted the task of delivering this address, I believed it would be quite an easy task to criticize the clean air strategy of the U.K., including the strategy of the best practicable means, from a European point of view. Then I read a few documents and so I learnt that the differences between the clean air policies or strategies of the U.K. and those of other European countries are not all that significant. Maybe, this is due to the fact that any clean air policy must basically be aimed at reducing emissions. Or, maybe, this is due to the fact that the problems of air pollution occurred in the U.K. first and therefore government action to improve air quality was initiated earlier here than in other industrial countries. So other countries have been able to benefit from the experience gathered here.

I think, it may be useful first to outline how I understood the U.K. approach to the control of air pollution after having studied the various documents.

The approval of stationary facilities is subject to the "Alkali Act". The operator of a facility is obliged to use the best practicable means for preventing the emissions into the atmosphere of noxious or offensive substances and for rendering harmless and

inoffensive such substances as may be so emitted.

The emissions from about 60 different types of facilities are settled by the provisions of the Alkali Act and approval and operation of these facilities are supervised by the Alkali and Clean Air Inspectorate. This means that the majority of industrial facilities presenting a particular risk of air pollution is covered.

Through the Clean Air Act of 1956 the local authorities are charged with air pollution control in their particular district. Type and extent of air pollution control, however, are up to the local authorities. This is based on the assumption that in rural areas only minor measures are required, whereas in industrial zones of agglomeration extensive measures are often required. Some local authorities initiated extensive measures and established special air pollution control sections. In other, mostly rural districts, a district inspector is sufficient to control the few problems arising from smoke or similar emissions. Action taken at local authority level are above all aimed at reducing emissions from smaller facilities, central heating and domestic firing installations.

The question of air pollutants emitted from vehicles has in the U.K. been settled by incorporating the EEC Directives into national law, as has also been done in the other EEC countries.

Surely, the above-mentioned legal regulations and the organization of air pollution control in the U.K. may require some complementary detail. I think, however, that this will be sufficient for the time being. Basically, the approval of new facilities and the improvement of existing facilities complies with emission standards which were laid down by the Chief Alkali Inspector. Two of these emission standards are statutory, i.e. finally established limits, while the other emission standards are presumptive limits, i.e. thresholds which are normally fixed for the individual facility to be approved. The Inspector, however, may under particular circumstances also set a lower limit, i.e. in the case of unfavourable topographical conditions or in districts with a high background air pollution. As in the case of the local authorities' activities under the Clean Air Act, appropriate individual decisions are also possible and necessary in the process of formulating the technical details of best practicable means.

The local authorities decide on type and extent of the action to be taken on the basis of the individual air pollution control requirements of their district. Similarly, the Inspector takes on-site decisions on the technical details to be observed to reduce

the emissions from individual facilities. The best practicable means or the emission standards are used as a kind of guiding rule. In individual cases, however, the Inspector may deviate from this guiding rule if this is necessary to ensure adequate air quality.

This way of organizing air pollution control, allowing a wide spectrum of free choice, is a very congenial regulation. It reflects a deep understanding for the forms of democratic government and is well adapted to the requirements of our dynamic industrial society. May I, nevertheless, add a few words of criticism.

Today air pollution control is only to a limited extent a local problem. We all know the warnings of scientists, such as those on the potential effects of regional and long-range transport of air pollutants, the formation of secondary air pollutants, the adverse effects of air pollutants even in the lowest concentrations - which may give rise to carcinogenic,mutagenic or teratogenic effects - or on possible world-wide climatic changes. Detrimental effects on highly sensitive animals or plants, caused by substances such as sulphur dioxide, are to be expected at concentrations far lower than the established criteria with regard to the effects on human health. Our concern is that ecological systems that are still healthy and viable today may be destroyed in a few years or decades. I do not intend to scrutinize whether and how far this may give rise to damage which might affect the quality of human life. However, I should like to state that today sufficient information on possible environmental damage is available which points to the necessity of not treating air pollution control as an exclusively local problem any more. Under this aspect I think that emission abatement requirements should at least be uniform within the entire territory of a state. Therefore this task should not be left to the local authorities who are naturally above all concentrating on local problems. It would certainly be even better to prescribe within the entire territory of the EEC - not only within the territory of each member state - uniform measures of emission control corresponding to the latest state of technology, although we are surely far from having reached this desired aim.

May I therefore note as the first point that it appears necessary to me under the aspect of clean air policy to establish uniform emission limits. These limits should be based on the latest state of emission abatement technology. These limits should have to be observed everywhere, even where local effects need not be expected, i.e. also in remote rural areas. I am absolutely unable to understand why emission control measures should not be enforced

everywhere, if this is technically feasible and bearable from an economic point of view. I am also unable to understand why the operator of a plant in a rural area should receive a kind of credit, whereas the operator in a large town should have to pay a kind of penalty. This would also remind me of the reproach from among the countries of the Third World that we are allegedly shutting down industrial facilities with high emission levels to export them to Third World countries.

In the last few years the principle of the best practicable means has been subject to some criticism which was nevertheless often unjustified. I think that any air pollution control concept should inculde measures designed to limit emissions and the specification of adequate chimney heights. In addition, requirements must be formulated for testing and monitoring emissions and for regular inspection of the plants. It appears to me that today this principle is hardly subject to controversy any more. However, as in many other cases, too, the difficulties arise from the detail. The establishment of emission standards is one of these problems, stack heights another. It is in almost all cases possible from a technical point of view to erect high chimneys - the problem is a financial one. Similarly, the effectiveness of facilities for the treatment of stack gas is primarily a financial matter, a matter of weighing the various air pollution control requirements against the economic aspects. The question is: "What is the goal to be aimed at?" If only local damage is to be prevented, the construction of a chimney will in many cases be sufficient. If general and supraregional aspects of environmental protection are included in the considerations, it will be necessary in the case of power plants, for example, to provide for stack gas desulphurization facilities, including an effective dust precipitator and a high stack. The stack is necessary in order to dilute adequately the residual emission of air pollutants which could not be removed despite all efforts made and as a last resort in the case of any accident, such as the breakdown of stack gas purification equipment. Particulate emission should be restricted to a minimum in order to reduce any effects from heavy metals and other hazardous components of dust, such as carcinogenic polycyclic aromates, to a minimum. Stack gas desulphurization facilities should bring about at least a standstill with regard to the continuous rise in sulphur dioxide emissions observed hitherto. Basically, it has to be decided in this context on which side of the scale to place the requirements for the limitation of emissions; whether more weight should be given to environmental protection or to economic aspects. This is a serious political decision. I think this decision can only be taken by the government after weighing all aspects against each other. Only the government is able to counterbalance the

economic power of industry by backing up the requirements of environmental protection and the citizens request for clean air. This weighing should not be left to the field inspectorate alone. In my opinion, the weights of power are not equal there.

Air pollution control in the United Kingdom is distinct from that of other states by a further point. As far as I know, no ambient air quality standards have been established in the United Kingdom. Measures of air pollution control are taken on the basis of technological practicability and not on the basis of information or specifications on permissible air pollution or existing pollution. The discussion on whether the strategy of best practicable means or the strategy of air quality management is better has been going on for many years. It always struck me that in the United Kingdom and in the United States these two opposing control strategies are perhaps best typified while in the other industrial countries of the Western and the Eastern World, a combination of both strategies is used in most cases.

Today, after many years' experience with the air quality management system we know that this system is by no means ideal. We are aware of the problems involved in the assessment of dose-effect relations, in the determination of representative and reproducible data on existing pollution levels and the difficulties arising from the practical application of diffusion models.

Nevertheless, there is quite a number of instances where an air quality management system is very useful and necessary. This applies in particular to planning in the case of larger areas with a great number of industrial premises and other sources and where the most effective solution has to be chosen from several conceivable solutions proposes. Cost/benefit analyses may only be carried out within the framework of an air quality management system - a point which is not disputed any more. Successful application, however, requires criteria and other indications with regard to the effects of air pollution and type and extent of necessary improvements. I think that, considering the experience gathered hitherto, the following specifications are required to make an air quality management system successful:

1. Specification of a "non-degradation or stand-still policy"

2. Specification of "ambient air quality criteria or standards" for the protection of human health

3. Specification of "ambient air quality criteria or standards" for the protection of fauna and flora and

4. Certain specifications with regard to the air quality monitoring system to be applied and the diffusion model in order to ensure uniform handling.

These points have also been included in the proposals of the EC Commission on the specification of air quality criteria. So far the approach of the EC Commission is that of air quality management and not that of best practicable means. Hitherto the proposals of the Commission do not contain any specifications on emission standards. The legal regulations of the United Kingdom do not contain any specifications on ambient air criteria or standards - that is, from a European point of view, both are incomplete.

So, may I add as a second point that it appears necessary to me from environmental and economic points of view to complete the strategy of the best practicable means by a few instruments of the air quality management system. In my opinion it would be of prime importance to establish ambient air quality criteria for the protection of human health and for the protection of plants and animals. These specifications need not necessarily be given by the government. Criteria may also be announced by an expert commission. I think, however, that at least some sort of guiding rule is required to assess the extent of air pollution with regard to its possible effects. The announcement or establishment of air quality criteria must not lead to the conclusion that air pollution below the degree specified by the criteria may be considered as harmless. The current state of knowledge does not allow such conclusions as yet. The establishment of air quality criteria must be linked with the declaration of a stand-still policy by the government. The combination of the best practicable means, air quality criteria and a stand-still policy is aimed at the following objectives:

1. The pollution load in already polluted areas should not exceed the criteria.

2. Any unjustified future increase in air pollution in areas which have been little affected by pollution hitherto should be prevented.

Both objectives appear equally important to me. We should use every available scientific and technological means to achieve better environmental conditions or at least to prevent any further increase in pollution. We cannot reach this aim by merely using technology, i.e. the best practicable means. Any consistent clean air policy must also consider other aspects. In addition to the above-mentioned instruments of an air quality management system,

opinions and behavioural patterns of the citizens would also have to be taken into account. In addition to the proper function of technical facilities it is also necessary that the citizens of a state are aware of the objectives of environmental protection.

It is these citizens who operate machines and thus take care that emissions are prevented or reduced. In many cases it appears more important and more promising to me to make them more aware of this responsibility than to pass laws or directives. This, however, is one of the points where the other European states could learn from the practice of the United Kingdom.

NATIONAL SOCIETY FOR CLEAN AIR

45th ANNUAL CONFERENCE
2-5 OCTOBER 1978
BRIGHTON

THE EUROPEAN APPROACH

by

P.J. Wilde,
Department of the Environment

136 North Street
Brighton BN1 1RG
England

INTRODUCTION

1. Despite its comprehensive title, this paper does not attempt a thorough-going comparative treatment of pollution control policies in the whole of Europe. The treatment is limited to the member states of the EEC and to policies for the control of industrial air pollution. Even within these limits a full study would demand at least a volume. However, I have tried in each case to indicate the broad framework of a country's policy and to bring out basic similarities and differences between the member states. I have not attempted a full discussion of the EEC environment programmes, which are a study in themselves.

2. The paper considers the character of the control authorities in each state, the structure of control, the use of air quality standards, the systems of inspection and emission control practised: in other words some central features of air pollution control policy.

3. There are obvious differences between the political systems of the member states, between the role of regional and local government, in climates, fuel mixes and industrial structure. But for the present purpose the basic similarities are perhaps more impressive.

4. The countries of the Community are all at roughly the same stage of economic and industrial development, using similar manufacturing techniques and processes. They tend to have broadly similar air pollution problems. Though fuel mixes differ, the basic problems stemming from combustion of coal and oil are to be found generally. These objective realities impose certain similarities of air pollution control policy, though these similarities are often obscured by differences of legal system and administrative structure. It is a main theme of this paper that though there are substantial differences in the instruments of control policy employed in the member states, which the paper tries to indicate, the actual practicalities of control do not differ nearly as much between states as a superficial examination might suggest.

STRUCTURE OF CONTROL

5. In all the countries, central government has overall responsibility for pollution control: in no case is this responsibility delegated to subordinate authorities. Also, however, common to each country, with the exception of Denmark, is a rather fragmented structure of central government responsibilities. In the

UK we have the Department of the Environment which has overall responsibility in England, but Departments such as Transport and Trade and the Ministry of Agriculture, Fisheries and Food also have some environmental functions by virtue of their other responsibilities. Similarly in France (though there has been some recent reorganisation) the Ministry for the Quality of Life co-ordinates policies, but shares some environmental responsibilities with the Ministries like Agriculture and Industry. In other countries, like Belgium and Ireland, there is not even a central government department charged with the protection of the environment; general policy matters are decided by interdepartmental committees on which all interested departments are represented. It is probably fair to say, however, that there is an increasing tendency towards the creation of a strong central department with specific environmental powers.

6. In many cases, the legislation enacted by central government simply provides a framework within which the enforcing authorities operate and set standards. The extent of local freedom varies. In Italy and Ireland, for example, all decisions are decentralised as a matter of principle, except where the national interest is concerned. In Denmark, on the other hand, the regional and county councils are subject to strong central government guidance. Somewhere in between are countries like the Netherlands where broad guidelines are laid down by the central Ministry for Public Health and Environmental Hygiene but where the local, particularly provincial, authorities have considerable authority, and West Germany, where again the Länder and the subordinate land authorities have wide powers to interpret and if necessary strengthen centrally established controls.

7. The complexity and difficulty of controlling many modern processes tends to produce a movement towards centralisation of control, because of the need for central resources and expertise to achieve adequate and co-ordinated control. The UK is interesting from this point of view, in having on the one hand a strong and well-established system of local government which exercises the majority of control powers, and also a small expert centrally controlled inspectorate charged both with the establishment of control requirements and their enforcement. The role played by the Alkali and Clean Air Inspectorate is unique in both breadth of responsibility and flexibility of approach, as the discussion later in the paper of emission control systems will indicate.

DEVELOPMENTS IN THE CONTROL STRUCTURE

8. The last decade has seen a tremendous growth in air pollution control legislation. A number of major reforming laws have been enacted: the 1970 Air Pollution Act in Holland, the 1973 Environmental Protection Law in Denmark and the 1974 Federal Immission Control Law in West Germany. And in the UK we have of course had the Control of Pollution Act 1974. All these laws have given the control authorities wider powers to tackle the problems of air pollution, although only in the case of Denmark has there yet been an attempt to create a control structure covering all media - not only air but also water and the land.

9. There are a number of reasons why so much legislation has been introduced over such a short period. The most important is the growth in public concern since the late 1960s about the dangers which pollution can pose both for man and his environment. This public awareness clearly served in many cases to focus attention on control powers which were not designed to cope with modern pollution problems, and on control structures which did not always lend themselves easily to a co-ordinated and expert approach to control.

10. In summary, EEC member states by and large use similar structures to control their air pollution problems. Of course the balance each state strikes between industrial activity and environmental protection will vary. Denmark, for instance, has explicitly given particularly high priority to pollution control as a policy area. Ireland, on the other hand, lays more emphasis on the importance of economic development and growth of employment. But despite these national differences, the pattern is perceptible: central legislation and, increasingly, standards or guidelines, and local enforcement and discretionary control within the central framework. What this similarity in structure also means is that it is the varying types of control used in other countries which are most useful for us to consider since it is here that the most interesting differences in approach occur.

AIR QUALITY STANDARDS AND GUIDELINES

11. As well as providing a framework within which controls are exercised, it is common for central authorities in Europe to attempt to stimulate the promotion of improved air quality. In pursuit of this, air quality objectives or standards have been established in Italy and West Germany and in the Netherlands, whilst Denmark, for example, has made provision in recent legislation for their establishment at some time in the future.

12. It is conventional wisdom that air quality standards have always played a greater role in continental Europe than in the UK. To some extent this is right - it must be since we have never had air quality standards. But their use in Europe may have been exaggerated in the past. Whilst the power to establish such standards has existed, the lack of monitoring facilities, of evidence of effects, etc., meant that comparatively few standards were actually created or applied. It is certainly not true to say that standards for large numbers of pollutants are used in all European countries as a major part of control policy.

13. Nonetheless, such standards do now exist in several countries. Although in many respects their use is still in its infancy (in Holland, for example, no link has yet been made between air quality standards and permissible emission rates), there can be little doubt that their use will increase. The role of the EEC is important here. The 1973 Community Environment Programme stated that a major way of controlling air pollution was by establishing air quality standards based on medically authenticated dose/effect criteria. Discussions are now taking place in Brussels on a directive which would establish health protection standards for smoke and SO_2. If the directive is agreed in its present form, air quality standards for these pollutants will have to be observed in all member states from 1981.

14. In the UK we have of course traditionally adopted an approach based on the control of emissions through BPM, in which air quality standards or guidelines played no explicit role, though of course any decision about emission controls involves some implicit judgement about air quality. We have monitored air quality to get some idea of how successful these controls were, but we have not tailored our controls to meet specific air quality objectives. This approach has of course considerable advantages. It has meant that controls have been based on what is practicable. It has also meant that they can be tightened progressively over time as new developments permitted. By and large, it is an approach which has served us well in the past. However, the Royal Commission on Environmental Pollution, in their Fifth Report, made the case for more attention to be paid to air quality, and for air quality guidelines to provide a framework against which a judgement about the efficacy of emission controls could be made. The Royal Commission argued for guidelines rather than rigid standards which could be difficult to enforce and which would not be justified by current knowledge of the effects of pollutants. This question of enforceability of standards is more important. For instance, the UK has accepted in principle the draft directive on Health Protection Standards for Smoke and SO_2. This leaves

the means of implementation in the hands of the member state. The standards required can be achieved in the UK by extension of the existing domestic smoke control programme, and possibly the use in some central urban areas of the powers in the Control of Pollution Act 1974 to control the sulphur content of fuel oil burnt.

15. But an unenforceable standard, or unrealistic air quality goal is worthless. There must be a practicable method of limiting emissions to achieve the desired goal. I think this is increasingly recognised in countries with experience of using air quality standards and guidelines. It is true that an ambitious air quality target may sometimes be chosen as a means of stimulating more vigorous methods of emission control. This has been the Dutch approach to some extent, but this way of proceeding is only likely to yield dividends if the emission control system is basically slack in the first place. Also there is a danger of over-reaction in the tightening of emission controls in such a situation. In the UK it has been argued that the activities of the Alkali Inspectorate ensure that industrialists do all that is practicable to control emissions without the carrot of an air quality target.

16. It follows from this that the role of air quality standards or guidelines within a control structure depends to some extent on how comprehensive and rigorous the system of emission control is. However, this is not to decry the value of some systematic attention to air quality. Indeed it is clear that the time has come when we must consider the case for the promulgation of realistic air quality guidelines. Quite apart from their value in setting explicit targets to be achieved from emission controls, they can have considerable value for land use planning and development control purposes.

CONTROL OVER EMISSIONS FROM DIFFICULT OR COMPLEX INDUSTRIAL PROCESSES

17. In the UK, emissions from industry are controlled either by central government (through HM Alkali and Clean Air Inspectorate) or by local authorities, depending on the process involved. This practice of treating separately those industries which, by their nature, are likely to be difficult to control is common to all member states, as is some method of licensing such industries. The section below describes the approach adopted by different countries:

a. BELGIUM: industrial installations are classified according to their potential effect on the atmosphere. The two most closely controlled classes are works which are potentially dangerous, and mines and open-cast workings. All such classified establishments, which are further sub-divided into classes depending on the scale of operation, must receive a licence from the appropriate authority - for small works this is the commune, for larger works the province. In granting the licence, account is taken both of the rather limited general legislation and of local circumstances, and where the commune is granting the licence it will usually seek advice from the provincial authority.

b. DENMARK: the Environmental Protection Law of 1973 lists those processes which "cause excessive pollution" and for which a licence must be obtained. These processes include iron and steel manufacturing, the quarrying and manufacture of lime, clay and coal, oil and natural gas treatment and chemicals. The licences are normally granted by the regional authority (although occasionally the responsibility is delegated to the counties), and the conditions are enforced by the municipal authorities. However, in all cases central government exercises considerable influence over the type of controls required.

c. FRANCE: Three categories of establishment are defined. An establishment falling into the first category must be sited away from human dwellings; one in the second category can only operate on condition that specified measures are taken to avoid danger, while one in the third category is subject only to general regulations. An establishment in the first or second category must be licensed by the Department (county) following a public inquiry. Inspectors of classified establishments are responsible for enforcing all controls over both licensed and non-licensed establishments.

d. IRELAND: the Alkali Act 1906 is in force, although it has not been extended to cover the same range of processes as in England and Wales. Thus in 1973 25 processes were scheduled, creating 18 registered works which were policed by 2 Inspectors. In addition, the Minister for Industry and Commerce is empowered to grant licences to smelt ore, manufacture cement, carry out mineral workings and explore, prospect and extract petroleum. He may attach to these licences "such conditions as he thinks proper".

e. ITALY: dangerous or offensive industries must be sited either in open country or must meet specific conditions in a town. The regulations are administered by the municipal authority,

which is responsible for laying down conditions with which the operator must comply.

f. NETHERLANDS: installations capable of causing extensive air pollution must receive a licence from the provincial authority, which may contain conditions.

g. WEST GERMANY: classes of works which cause particular danger or nuisance are required to be licensed. These classes - in all 58 - are laid down by Federal ordinance and cover about 15,000 works. Licences are issued if it can be shown that the operator will comply with legal requirements established by the Federal, or Länder, authorities and more detailed controls are imposed by means of conditions attached to the licence. The licences are issued by the Länder authorities. Inspection is in the hands of general 'Trade' Inspectors, whose functions embrace those of Alkali and Factory Inspectors as well as other duties. They thus tend not necessarily to be expert on particular processes.

18. As well as having in common special arrangements for difficult or dangerous works, the types of control required of such industries are also broadly similar. For example, prior approval is normally required for the construction or alteration of a licensed installation. Emission limits, centrally or locally determined, are normally used. Minimum chimney heights are often specified, and in some cases conditions are made about the pre-treatment of discharges to the air.

ESTABLISHMENT OF CONTROLS

19. In the UK, the central control authority (the Alkali Inspectorate) uses the concept of 'best practicable means' as the basis for what is required from a particular works. In formulating bpm a variety of factors are taken into account, including the current state of technology, local circumstances and the economic implications of the controls. In many cases, observance of a centrally established emission limit (reached after consultation with the industries involved) will be taken as evidence that bpm is being used. Chimney heights, of course, may vary according to local conditions.

20. The bpm concept as applied by the Inspectorate is unique both as regards the comprehensivity of its requirements (prior approval of equipment, condition of plant, training of operators, monitoring etc.) and as regards the expert character of the district inspector and the consequent local discretion which he is left to exercise in dealing with a particular plant.

21. The centre-point of bpm is the consideration of what is technically feasible together with what is economically and financially feasible. This trade-off is central to most emission control systems used in the Community. Thus in Denmark decisions about the controls to require must take account of economic as well as environmental factors. In the Netherlands, 'best technical means' is only required when it is felt that the use of 'best practicable means' would give insufficient protection. In West Germany, the requirement to use best available technology implies not only technical, but economic, practicability. The evidence suggests that although different countries use different philosophies as a basis on which to establish controls, in practice the factors which are taken into account do not vary very much.

22. However, to return to the point of flexibility, there is a distinction to be drawn between the bpm system as it operates in the UK and the licensing system used by most European countries. BPM is a dynamic system. It can be amended over time to take account of technological developments or changed local circumstances. Thus more stringent controls can be imposed progressively as they become practicable. With a licensing system, on the other hand, once the licence is issued, it can be more difficult to alter its terms, if it constitutes a binding legal document. This implies that the scope for progressive improvement in controls is very limited. For example in West Germany, once a licence is issued, the authorities may insist on further improvements only if either Federal air quality standards are not met, or public protection is not adequate. Otherwise the operator is under no pressure to improve his performance. While it can be argued that licensing in this way has the the advantage of letting both the operator and the control authority know exactly where they stand, its inflexibility is a major drawback.

THE CONTROL AUTHORITY

23. Another difference between the UK and most of its European partners is the tier of government to which the authority responsible for issuing the licence, or permission to work, belongs. As a general rule, those industries or processes which are the subject of special controls are centrally determined. But the extent to which the actual controls are locally determined, and the degree of central guidance provided, varies considerably. In the UK, the Alkali Inspectorate is, of course, an independent arm of central government. The Alkali Inspectors are technically expert, have wide experience and deal only with this type of work. In other West European countries, by contrast, the

authorities responsible both for granting the licence and for enforcing its provisions are invariably from local government. In most cases the licensing authorities, in particular, come from the top tier - provincial or regional authorities - but sometimes, in Belgium for example, the municipal authorities are responsible. The authorities are of course, generally provided with some central guidance on which to base their decisions. The amount varies from country to country. But no other country has the same kind of central expert body as the UK to deal with difficult works. The great advantage of a central body like the Alkali Inspectorate is that it imposes controls which are consistent. They are also based on expert knowledge which is likely to be unavailable to all but the largest authorities in other countries. This lack of expertise has been openly criticised in some countries. In Belgium there has been criticism not only of the lack of uniformity - there are few centrally established guidelines so the controls imposed have varied significantly - but also lack of knowledge on the part of the control authorities.

OTHER CONTROLS

24. The control system for other works, not subject to special controls, is broadly similar in all member states. Local authorities are usually responsible for enforcement, although in some cases the controls themselves will be laid down by the central authority. There are extensive controls over visible and easily detectable pollutants like smoke, grit and dust. In many cases, emissions of dark smoke are either banned or limited in time. Chimney heights, particularly for combustion installations, are often specified, and heating equipment is frequently required to meet technical specifications. Building regulations and planning procedures also play an important role: for example, in the equivalents of our structure plans regard must often be paid to the polluting effects of industry. Most countries also have some equivalent to our nuisance provisions, which provide them with a general means with which to control pollution. In sum, there are no significant differences in the approach which different countries take to the more straightforward pollutants and sources.

CREATION OF SPECIAL ZONES

25. A major aspect of air pollution control policy in some EEC countries, which has no parallel in the UK, is the existence of 'special zones', where particular control measures are required because of the characteristics of the area. These areas can either be those where pollution is high and where special measures are

necessary to prevent an increase - and ideally achieve a decrease - in existing levels, or those where pollution is low and where it is desirable for environmental and social reasons that it should remain so. The list below describes the types of zones which exist in different member states and the particular controls which are imposed in them:-

a. BELGIUM: 'special protection regions' have been created where sulphur pollution is considered to be high. In these zones, all emissions of smoke from furnaces are banned, and furnaces must comply with stringent and centrally-established technical requirements.

b. DENMARK: under the 'zone law', the country is divided into urban and rural areas. In rural areas, there is a general ban on new development, although on occasions this ban can be relaxed.

c. FRANCE: in areas where existing pollution, or density of population, is felt to justify special protection, special measures are taken to keep pollution below a level fixed by central government. These measures include emission limits, and restrictions on the use of particular fuels.

d. ITALY: zones with a certain population density or of particular natural or cultural interest are given special protection by means of regulations applying to new thermal plants. In addition, operators in these zones must as far as technically feasible avoid emissions which will add to atmospheric pollution. Particular control devices are prescribed and emission limits set. Where an air quality standard has been set and the permitted level reached, new industrial plant emitting pollutants is banned.

e. WEST GERMANY: 'special areas', like spas and nature reserves, may be protected by a ban or limit on the use of certain fuels, or a requirement that installations only operate at certain times. In designated 'heavy pollution areas', the provincial government draws up clean air plans. These plans state the nature and extent of existing and expected pollution, the cause of this pollution and the measures that should be taken to reduce it.

26. In the UK, our domestic smoke control programme is probably the nearest we come to creating 'special zones', although this is of course aimed at the domestic rather than the industrial source. The City of London, where a limit on the sulphur content of fuel oil is being applied progressively, is the only example of a particular area where a blanket control over industrial emissions is being enforced. In practice, of course, our existing planning

law means that new development is not normally permitted either in highly developed or residential areas, or in areas of natural beauty. However, this still leaves a gap in those areas where there is large-scale development and where the air quality is already poor. Whilst we have piecemeal controls - the powers of the local authority and the Alkali Inspectorate (the latter taking account, of course, of local conditions) - we do not use any control mechanism to apply a particular form of control in a blanket fashion to a specified area.

PRODUCT STANDARDS

27. So far, this paper has concentrated primarily on the structure of control and the methods used to abate or disperse emissions which a process produces. However, product standards also play a significant role in the control of air pollution in most European countries. The most common restriction is on the lead content of petrol, and these various national limits have been harmonised by a recently agreed EEC directive, which involves a general commitment to a limit of 0.4 grams per litre from 1981. Sulphur is another major pollutant sometimes controlled by the use of product standards. Again there is an EEC directive on the subject, this one limiting the sulphur content of gas oil. The way in which national product standards for sulphur in other fuels are applied varies from one country to another. In some cases - Belgium, Germany and Italy - the limits are imposed only in particular regions, while in others - Denmark, the Netherlands - the controls are nationwide but the actual restrictions vary, depending on the characteristics of the area.

28. In the UK, we do not impose general limits on the sulphur content of fuel oil. The City of London has controls under its own private legislation. The CEGB observe limits on the sulphur content of the fuel they use as part of the BPM requirement of the Alkali Inspectorate. Controls of this kind can be useful, but can equally be very wasteful if pursued regardless of local fuel mix. For instance, there is no point in controlling the sulphur content of fuel oil if the major proportion of sulphur pollution is caused by something else. Thus the UK has opposed a draft EEC directive which would have required a limitation to be placed on the sulphur content of fuel oil in all areas of high sulphur pollution, irrespective of how the sulphur pollution was caused.

29. The example of lead in petrol shows clearly that product standards have a role where there is a problem apt for control on a general rather than a local basis, where for instance a

widely traded good is involved, or a mobile source of pollution. The basic criterion of choice between means of control, as always, must be practiability of implementation and cost-effectiveness.

THE COSTS

30. One thing all pollution control policies have in common is that they must be paid for. Resources used for environmental protection are not free. Who should pay? Society at large? The consumer of the particular good? All member states of the Community subscribe in principle to the proposition that 'The Polluter Pays'. Of course the principle does get bent a little at the edges. In France grants are sometimes paid to polluting industry to help with control costs. In Germany special depreciation and cheap credit arrangements are available for air pollution control investment. Denmark is also considering the possibility of giving financial relief to the polluter in instances where economic factors - for example the extent to which a factory provides essential employment - play a major role. Examples of this kind, where there may be a direct clash between economic and environmental arguments can expose in an acute form the basic dilemma of pollution control. Where does the balance between environmental protection and economic activity rest? There is no one answer to that valid for all times and places. Changing public expectation, political will and economic prosperity all have their influence. But the basic theory that the polluter pays is the foundation of policy in all Community states.

CONCLUSION

31. This paper has been an attempt at a brief review, evaluation and comparison of some of the more significant and striking features of the air pollution policies pursued in the Community, as viewed from the UK and with a background of UK policies in mind. It has not touched on some important areas such as monitoring and research expenditure and programmes. It has concentrated on the immediate issues of industrial controls. A basic theme has been the degree of practical similarity to be found in the different countries, despite legal, administrative, and constitutional differences. I suspect the similarities are increasing rather than diminishing, particularly as there is increasing consciousness that air pollution is an international rather than just a national policy area.

32. The most obvious difference between UK practice and that general elsewhere is perhaps our lack of explicit attention to air quality, to which the Royal Commission on Environmental Pollution has drawn attention. The paper says something about the way in which the operation of BPM has perhaps obviated the need to attend specifically to air quality in the past. But it seems evident both from the Royal Commission's Report and the response to it, and from our participation in the EEC environmental programmes, that we are going to do so increasingly in future.

33. There is little doubt that our system for the control of industrial emissions will bear comparison with anything done elsewhere. Our possession of an expert central inspectorate with a high reputation built up over the years is of central importance here, as is the Inspectorate's relationship with industry, as is also its capacity to require monitoring and to conduct tests. There are of course, recommendations of the Royal Commission which are under consideration at the moment (notably BPM powers for local authorities), to strengthen the system, together with the forthcoming review of the law of statutory nuisance.

34. There is no point in uniformity for its own sake, and I do not think we should achieve it in all aspects of environmental policy even if there were. However, though different control instruments may be in use in different countries, and varying weight may be given to particular factors, the basic structures of air pollution control policy and problems in the nine countries are not very dissimilar. Allowance must be made for differences in law, constitution, historical background, and administrative practice, together with material factors such as climate and fuel mix. Some countries put more emphasis on quantified standards, some more on subjective judgement of conditions; some have centralised systems, some devolved; the balance between environmental protection and industrial activity varies. But at the least there is a common frame of reference for national air pollution control policies in the Community.

35. The examination of other national policies is valuable whether it results in reassurance about UK policies or suggests the possible desirability of alternatives. Whatever conclusion we reach today about the relative efficacy of our own or others' air pollution control policies, we can at least be assured that the subject has come a very long way since Lord Derby on 9 May 1862 moving for the Committee which led to the Alkali Act of 1863,

raised the subject of air pollution 'in the absence of more exciting topics for discussion'. Whatever may now be said about the comparative merits of different policies air pollution control is established as a significant part of public administration, as an important area of social policy throughout the European Community.

NATIONAL SOCIETY FOR CLEAN AIR

45th ANNUAL CONFERENCE
2-5 OCTOBER 1978
BRIGHTON

THE TASK OF THE LOCAL AUTHORITY, MONITORING, MEASUREMENT, COLLECTION AND DISSEMINATION OF INFORMATION

by

L.E. Robson,
Environmental Health Department,
City of Bristol

136 North Street
Brighton BN1 1RG
England

1. INTRODUCTION

1.1 It has often been quoted that the growth of the environmental movement has been one of the more striking features of the second half of the twentieth century. In my comparatively short fifteen years in Local Authority employment I would whole heartedly agree with this comment. Certainly today there is a feeling that man's activities have brought about changes in the balance of nature and that he needs to take more careful account of the effects of his action on that balance, and use his skills not only for his own economic advantage but as a trustee for the whole of nature, its preservation and conservation. Ancillary to this feeling there is a growing desire, among the populace, to obtain a greater influence in the policies and decisions which affect their lives, and the surroundings in which they live and, also a greater desire to know the consequences that are likely to occur by the adoption of such policies and decisions. Those responsible for Local Authority management, both at officer and elected representatives level, can no longer take decisions based strictly on the economic consideration. They must also take account of environmental costs and benefits in a wider sense.

1.2 When I qualified as an Environmental Health Officer, the most significant legislation that affected the environment was the Public Health and Housing Acts. However, the growth of interest in the environment has been a major political force and it has been exemplified in the proliferation of environmental pressure groups in many countries. Such movements have a serious purpose and have been taken seriously both by national governments and international bodies. There is clear evidence in the field of pollution control of the search for higher standards. The movement towards unification and standardisation of law is shown by the setting up of various agencies, such as the Environmental Protection Agency in the United States of America, the Royal Commission on Environmental Pollution, the establishment of the Department of the Environment in this country, the United Nations Conference on Human Environment at Stockholm in 1972, and the current progress and concern of the E.E.C. and O.E.C.D. countries with policies about control of pollution in its widest sense. Ancillary to this interest in pollution is the increasing concern to ensure that decisions, relating to projects and development programmes, and the formulation of national policies, are based on proper consideration of likely environmental consequences.

1.3 The dictionary definition of environment is "surrounding, surrounding objects or circumstances", but this is capable of many interpretations. To me the environment embraces the whole picture

of human, animal and plant life and their interactions. I believe that it is this interpretation that Local Authorities should adopt when implementing their statutory and moral obligations to the public whom they serve.

1.4 The disciplines and organisations that are concerned with the protection of the local environment, include District and County planning authorities; Environmental Health Authorities at District Council level, and Area Health Authorities on a regional level. Other public bodies with powers of control over emissions, include Water Authorities, Waste Disposal Authorities and the Health and Safety Executive. Other organisations with scientific expertise in the environment and the effects on it of various kinds of development are the constitutional bodies of the National Environmental Research Council, the Nature Conservancy Council; the Professional Institutes, scientists in Universities and Research Institutions and the advisory services provided by the Ministry of Agriculture Fisheries and Food. However, each of these respective organisations is entrusted with individual powers and in most cases there is no overall view of the subtle changes on the total environment that are brought about by individual actions or events. This point was noted fairly critically in the Fifth Report of the Royal Commission on the Environment, in suggesting the possible need for a unified inspectorate. In the 1* absence of such an inspectorate it is quite clear in my view that the individual district Local Authorities, being the elected representatives at grass-roots level, must do everything possible to encourage a total view of the environment, promoting the integration of all the available specialist expertise for the overall benefit of that environment.

1.5 District Councils through their officers, that is the complete range of professions - Engineers, Planners, Housing Managers, Surveyors and Environmental Health Officers - must monitor the small discrete changes in their programme areas that have been caused by natural events or, as a consequence of local policies on land use, including housing, transportation, and planning matters. The changes that can occur can affect either:

(a) the natural environment, of flora and fauna, insect life, organisms and ecological regimes in terrestrial or aquatic habitats, and/or

(b) the human environment, which includes the aesthetic quality of the physical and natural environment and impact on employment and health. These may be experienced by the presence of physical hazards, polluting emissions to water, land and the atmosphere,

including solid waste disposal and radiation; nuisance affecting health comfort and convenience arising from grit, dust, fumes, heat, light, noise, vibration, and wind; safety and convenience of pedestrians through changes in movement and traffic; and finally the impact on social and cultural well-being arising from the breaking up or disturbance of existing communities or groups, severance and changes in homes and neighbourhoods and, the disturbance to or, loss of recreational facilities. All these impacts must be assessed corporately by the Local Authority. Those issues that affect the natural environment, and affect health, safety and convenience of the population, should, I believe be looked at by Environmental Health Officers in the District Authorities, by using the various wide ranging powers that are available to them, both mandatory and discretionary.

2. LEGISLATIVE POWERS FOR MONITORING OF THE ENVIRONMENT

2.1 Legislative powers have been available for a very long time to Local Authorities in relation to the carrying out of research into problems relating to atmospheric pollution. The Public Health Act 1936, Section 105, made powers available to Local Authorities to undertake investigation and research into problems relating to atmospheric pollution and the abatement of smoke nuisances, and also provision for the making of contributions towards the costs of similar investigation and research undertaken by other bodies or, persons. As far as I am aware very few authorities used these powers. Some twenty years later these provisions were re-enacted in the Clean Air Act of 1956, Section 25, which in turn has subsequently been repealed by the Control of Pollution Act 1974, Section 79, which provides that, "(1) A Local Authority may (a) undertake or contribute towards the cost of investigation or research relevant to the problem of air pollution and (b) arrange for the publication of information on the problem." It is significant to note that the wording in the Control of Pollution Act 1974 is similar to that of Section 25 of the Clean Air Act 1956, and to recognise that the provisions of sub-sections (c), (d), and (e), of the latter have not been repealed by the Control of Pollution Act, and thus a Local Authority is still able to arrange for delivery of lectures and addresses, and the holding of discussions on the problem of air pollution. These may include the display of photographs, films, holding of exhibitions relative to the problem, the preparation, sharing in, contribution to the cost of the production of photographs, films, models, or exhibitions to be displayed or held.

2.2 In addition to the powers that are available to obtain information regarding emissions generally by way of investigation or research under the Control of Pollution Act, it is significant to note that Local Authorities are able to require measurements to be carried out or, are liable to have to carry out measurements themselves of grit, dust and fume emissions from chimneys, in relation to certain defined categories of combustion furnaces. These powers may be used where pulverised fuel or any solid matter is burnt at the rate of 100lbs an hour or more or, any liquid or gas is burnt at the rate equivalent to 1,250,000 BTUs per hour or more. Such measurements have to be carried out in accordance with the Act, and the provisions of the Clean Air (Measurement of Grit and Dust from Furnaces) Regulations 1971. Measurements normally follow the service of a notice and can in respect of the large size plant be carried out by the industrial company themselves or, in respect of the smaller industrial furnaces, the occupier can request that the Local Authority carry out the measurements themselves at the Authority's own expense.

2.3 Environmental Health Departments also have the power to initiate investigations into fume and odour problems under the provisions of the Public Health Act 1936, Section 93, (the nuisance provisions). Further powers are provided to inspectors appointed under the Health and Safety At Work Act 1974, Section 20, (1)(f) and, (1)(g), to take measurements, photographs and to take samples of any articles or substance found in any premises where they have power to enter, and of the atmosphere in the vicinity of any such premises. Inspectors appointed for this purpose include the Factory and Alkali Inspectorate of the Health and Safety Executive and Local Authority 'Authorised Officers'. The main premises covered by the Local Authority inspectors are non-industrial premises.

2.4 Reference so far to the legislative powers has been made purely in relation to the controls over atmospheric pollution. There are, however, extensive powers available to District Councils in relation to noise under the provisions under the Control of Pollution Act 1974. These deal with noise nuisance, which affects the public, whether arising from domestic, commercial or industrial activities. The powers of investigation under the Act do of necessity involve inspectors in extensive monitoring of the environment.

2.5 Collectively, the various Acts give Local Authorities a wide range of powers to carry out environmental monitoring in its broadest sense. However, not all use these powers to the full,

principally I feel either because they do not have the staff or financial resourses to carry out this work or have not identified problems that prevail which necessitate recourse to measurement. However, my authority does carry out extensive monitoring within its area. This involves the monitoring of the internal environment of premises, where we are the enforcing authority, and routine external monitoring of industrial, commercial and domestic premises. My department also undertakes specific monitoring programmes into environmental effects of transportation, industrial, housing, planning and recreational policies.

3. BRISTOL'S LOCAL ENVIRONMENT

3.1 The monitoring programme of the Environmental Control Division of my department can be sub-divided into routine work and specific surveys. Both of these include areas of work which could come within the definition of "research and investigation into air pollution". For those who are not conversant with the City of Bristol it is sufficient to say that the City itself has a population of approximately 420,000 and covers 27,068 acres. Although there are many areas in the City that contain small pockets of industry, the major industrial area is that generally called Avonmouth/Severnside. Avonmouth is a low lying, naturally marshy area situated at the confluence of the Rivers Avon and Severn and some seven miles north-west of the Bristol City centre. The effect of the low marsh creates a high dew point and under certain weather conditions temperature inversions are common. As a norm the prevailing wind is from the south-west, though a definite north-east component can be observed in some seasons. The Avonmouth industrial area covers approximately 1,750 acres of which approximately 800 acres have been developed for industrial purposes. A remaining 700 acres are reserved for future similar development in the Severnside estuary.

3.2 Contained in this industrial area are a selection of heavy industries: the largest continuous primary lead and zinc smelter in the world currently producing 95,000 tons of zinc and 30,000 tons of lead with associated plants producing approximately 150,000 tons per annum of sulphuric acid; manufacturers of nitric acid, phosphoric acid, and ammonium nitrate; pharmaceutical products and a wide range of organic chemicals. The combination of productive capacity present makes this area the largest producer of nitric acid in the world and, thus the potential emission situation involves substantial mass emissions of oxides of nitrogen. There also exists a plant which has the capacity to

manufacture sulphuric acid at a rate of approximately 40,000 tons per annum, hydrofluoric acid at a rate of about 35,000 tons per annum, refrigerant gases and aerosol propellants, aluminium sulphate and Boron Trifluoride. Other newer products in smaller quantities are being produced in the area for the drug industries, including Fluoroaniline. Total production of phosphoric acid, created by the reaction of sulphuric acid on phosphate rock, reaches about 100,000 tons per annum. There is additionally a company which produces a wide range of organic chemicals and is involved in the reprocessing of waste oil products, resin manufacture, specialist materials for the paint and varnishing industry and organic solvents. Another company produces carbon black from the partial combustion of a heavy fuel oil under controlled conditions. The plant manufactures 100,000 tons of black per year by both the thermic and cyclic processes. An associated company of the former, manufactures bricks in a continuous Dutch kiln. A municipal refuse disposal incinerator is also located in the area, burning household and industrial refuse, at a rate of 30 tons per hour.

3.3 In addition to these heavy metal and chemical processes, there are a number of manufacturing and distributive industries in the area, most of which have grown up around the Avonmouth Dock complex. There are a number of flour mills, a bakery, a beer bottling plant and companies which process imported grain and oil seeds for use in compounding animal feedstuffs. The animal food and grain processing industries are near the docks, with chemicals, oils and petroleum storage td the north. The whole of the industrial estate is bounded to the east by a residential area, which has a population of approximately 20,000. Development has naturally been fostered because of the good communications created by the water and the motorway network which runs through the area. It is coincidental, either by way of good planning foresight or by good luck, that the M5 motorway divides the residential areas from the industrial estate. The industrial area extends beyond the boundary of Bristol into the neighbouring district of Northavon District Council which shares our deep involvement in the monitoring and control of atmospheric pollution.

4. ROUTINE ATMOSPHERIC POLLUTION MONITORING

4.1 Environmental monitoring in Bristol commenced in the early 1950's by use of standard deposit gauges. These were later complemented by one set of daily volumetric equipment for smoke and sulphur dioxide measurement. This was situated near to the

city centre, the results being submitted as part of the National Survey. In 1969 I was appointed Specialist Inspector for atmospheric pollution and noise control and had the opportunity to reappraise the City Council's monitoring programme. It was clearly evident that there were monitoring needs in the inner city areas, where there existed congested housing and where monitoring results were needed to substantiate further extension of the city smoke control programme. In addition, the number of complaints made by the public continued to rise steeply regarding problems associated with air pollution incidents, particularly where residential property was adjacent to industrial estates, in particular in the area of Avonmouth/Severnside. Concern by the public was being expressed in relation to the problem of lead in the local environment, as there had been reported deaths of horses grazing in the Avonmouth area. Questions were being posed by the public which the politicians and officers were unable to answer in full without monitoring facts. Thus the political will was established for a proper appraisal of our monitoring needs and resources were made available.

4.2 The equipment type and its location have been carefully appraised, having regard to both the actual and potential nature of emissions from industrial premises. Such a development has only been able to take place with the co-operation of industry and the local Alkali Inspector of the Health and Safety Executive providing the local authority on a confidential basis with details on which to programme our work. The selected location of sites and the appropriate equipment has been carefully chosen to ensure there has not been a duplication of the monitoring activities carried out by industry and also to ensure that a common method of monitoring and the expression of results. This has allowed the results of both industry and the department to be commonly collated and interpreted.

4.3 At present there are seven monitoring stations using the daily volumetric method, maintained by the department for the monitoring of smoke and sulphur dioxide, strategically placed not only in and around the industrial estate but also in residential areas and the city centre. We have two portable smoke and sulphur dioxide monitors which are used on a rolling programme for the assessment of pollution in future smoke control areas. The results obtained from the above are very reassuring, both in respect of smoke and sulphur dioxide, particularly when compared with other urban areas in the UK. It is significant to note the results derived from the monitoring stations that 2*
are near to the industrial Avonmouth complex, which shows the smoke values well below (about 40% on average) the town average for

comparative sites in the United Kingdom. Sulphur dioxide levels are also below urban averages (about 20% below the 1968/70 averages) for the City Centre. All our results are consistently higher in the city centre for both smoke and sulphur dioxide levels, than those in the industrial area of Avonmouth. It is quite apparent from our results that the draft E.E.C. directive 3* for Health Protection Standards, Sulphur Dioxide and Suspended Particulates in Urban Atmospheres, is already being met in the Bristol area, and therefore there would be no need for the Authority to consider setting up Special Protection Zones in which the sulphur content of fuel oils would have to be progressively reduced to satisfy levels by a specified date. (As a first approximation special protection zones can be defined from the 80 microgram per cubic metre smoke contours and the 150 micrograms per cubic metre sulphur dioxide contours on the 1972/73, 1975/76 Warren Spring laboratory winter mean contour maps.) 4*

4.4 My authority has, as already indicated, a long history of operating standard deposit gauges. These instruments are essentially a method of estimating general levels of pollution, by the monthly results of fallout and the long term assessment of trends. In all, the authority operates seven such gauges, three of which contribute towards the National Survey. The National Survey of grit and dust is concerned with the insoluble portion of the particulate matter which falls out of the air by its own weight. It is largely made up of ash, unburnt solid fuel, windborne dust from roads and from industrial installations, including those handling solid materials in the open, (e.g. coalyards). Since the particle size tends to be well above the respirable range, this material is not usually regarded as a hazard to health. It can, however, be a severe nuisance and thus the results from such instruments are interpreted with due regard to the proximity of known emission sources, such as power stations or large furnace plant. The report published by Warren Spring Laboratory on the National Survey of Air Pollution concluded that the yearly averages for insoluble deposits had shown no general change in medium or peak pollution levels since 1963, and that regional variations were much less marked than in the case of smoke and sulphur dioxide. An examination of the results for Bristol over the last ten years fails to show any general change in the trend of deposition level. It is interesting to note that the general level of deposits in respect of three of the sites run in my area, which are used for national survey purposes, the highest figures are to be found at those stations located nearest the centre of the City. The lowest are, as one would expect, in the more open park areas of the City, and the intermediate values are to be found near to the Avonmouth industrial estate. Apart

from the insoluble portion of material collected monthly in the standard deposit gauges, an investigation is also made by the Authority of the soluble portion that is washed out in rainfall. Determinations have been made for us by Avon County scientific adviser for trace elements, and these deposit gauge results are used as supplementary information to our other heavy metal - monitoring activities. For example the level of lead deposited in these gauges is available expressed as milligrams per square metre per day ($mg/m^2/day$). For Avonmouth the deposits have been in the region of 1-3 $mg/m^2/day$ around the industrial estate, particularly near the lead smelter. Almost all of this lead is water soluble and these amounts appear not to be unusual for an area subject to heavy traffic and close to heavy industry, though little national data is available for comparison purposes.

4.5 Routine continuous air monitoring for heavy metals is now carried out at eleven sites in my district. Four metals - lead, zinc, cadmium and copper, are determined on a weekly basis using specifically designed equipment, comprising a pump which draws in 10-15 litres of air per minute, through a membrane filter having a pore size of $0.8\ \mu$. The air flow is registered by a gas meter to enable the results to be determined in $\mu g/m^3$ (micrograms per cubic metre) for Pb, Zn, Cd, Cu. The stations are at fixed locations monitoring on a continuous basis, 365 days a year. In addition to the 11 stations, the city also possesses a further 9 sets of similar instrumentation which is used for research and specific investigations. Our work around the City on all the sites indicates that the results in Bristol are satisfactory, and that the draft directive of the E.E.C., which proposes a mean 6* annual level of (2 micrograms per cubic metre) 2 $\mu g/m^3$ in urban residential areas, and a monthly median level of 8 $\mu g/m^3$ (micrograms per cubic metre) in areas particularly exposed to vehicle traffic, is not being exceeded. Indeed all sites in Bristol showed results that are below the lower standard. It is gratifying to both industry and the City Council to note that when we carried out monitoring during long periods of smelter shutdown, the monthly mean in the surrounding areas has been of the order of 0.5 $\mu g/m^3$ of lead in air, and when the smelter has been in full operation this figure has only risen to a maximum of 1.5 $\mu g/m^3$ in nearby residential areas, with the majority of results being much less than this level. The levels obtained in the Avonmouth area, both by my Department and by the company, show that levels of lead in air, other than in the immediate vicinity of the smelter's perimeter, are comparable with those found in the City Centre and East Bristol, the latter of which is an area of dense housing, with no known major emitters close to hand.

4.6 It has been clearly established from the department's industrial emission and process inventory that there are industrial processes in which fluorine and its compounds are discharged to atmosphere. As a consequence the City Council, in co-operation with one industry, has set up a low cost method of monitoring fluorides, (development by Mr. R.W. Wakeley, 7* Commonwealth Smelting Limited), which relies on the free circulation of air around a limed filter paper. Absorption of gaseous fluorine and airborne fluorides into the paper is measured after one month's exposure, and a calculation can be applied to convert the results to an equivalent atmospheric concentration. The City Council operates 5 such sites around known emitters. The amounts measured are small and are of no known consequence to human health, but for certain types of cattle it is believed that as little as 1.0 $\mu g/m^3$ of fluoride in air measured continuously may be important. It is also known that fluorides can cause damage to vegetation. From our most recent monitoring results, maximum (not average) results have gone up to 2.0 $\mu g/m^3$ and this is an area which warrants further specialist evaluation and at present does influence land use policies.

4.7 Grassland monitoring is carried out on a regular basis by the City Council in conjunction with industries at Avonmouth and Officers of the Ministry of Agriculture, Fisheries and Food. The City takes a minimum of five samples a month of grass from fields surrounding the industrial estate and from control sites, for the determination of leads, zinc, cadmium, copper and fluoride. The method of sampling and analytical determination has been carefully calculated and programmed so that samples are taken by using standardised techniques. In addition to the routine grassland survey, the City has from time to time taken rhine (a local term for the ditches employed for land drainage) water samples, vegetation samples and soil samples, in and around the main industrial and residential areas, analysis being made for heavy metals. The principal reason has been to establish if there is correlation between the result of the other monitoring techniques, to ensure that no untoward accumulation has built up in any of the systems which could either affect humans and, or, animals through the food chain.

5. POPULATION MONITORING

5.1 Blood lead surveys, of the children in Bristol, and the children of lead workers, have now become a routine procedure every two years in the City. It is considered that

whatever the recorded levels of the environmental pollution maybe, they are only of significance to human health insofaras they may result ultimately in the absorption by the population of harmful quantities of toxic substances. In recent years, because of particular local industrial circumstances, special attention has been paid in Bristol to lead. Lead can be absorbed into the body from the environment, either by ingestion by means of food, drink, dust or dirt, or by the inhalation of microscopically small particles. Increased levels of absorption cause, in the first instance, a rise in the amount of lead detectable in the blood, so therefore, the blood lead level is a good indicator of fairly recent absorption rate. Some of the absorbed lead will be deposited in the skeletal tissues, where it tends to accumulate over the years, some will be deposited into the nails and hair. Should there be excessive absorption leading to excessive tissue levels, there may be consequent effects on the nervous system. Some researchers believe that they have demonstrated that mental retardation in children can be caused by lower levels of lead absorption than those currently considered acceptable. Whilst these reports have stimulated further research, they are by no means at present, universally accepted. Dangerous levels are usually found only in persons exposed to very heavy contamination, either in the course of their occupation or where some unwise activity occurs, such as the uncontrolled burning of old car batteries or where young children chew lead contaminated paint-work. Children are much more sensitive to lead absorption than adults so that monitoring activities should be particularly aimed at assessing the situation in relation to small children living in a community.

5.2 It has generally been accepted in the past that blood lead levels in children should not be allowed to rise above 40 micrograms per hundred millimetres of blood, (1.9 micromoles per litre) and that in any case they should be kept as low as possible. More recently the Commission of the European Community had proposed a 8* frequency distribution with 20 µg/100ml (0.96 micromoles per litre) as a median and 35 µg/100ml (1.7 micromoles per litre) as the upper acceptable limit for people not occupationally exposed to lead, and according to expert medical opinion, any level above 35 is considered undesirable. The population at large is exposed to lead in food and water (arising from lead water pipes in older houses) from paintwork (particularly old paint), from the exhaust fumes of cars using high octane petrol containing 'anti-knock' agents, and from industrial emissions. On balance, lead levels in urban populations are raised by comparison with those in rural communities.

5.3 In 1972 it was decided to carry out a survey of blood levels in Bristol children between the ages of two and five, and later amongst school children. In all, over 1,000 individual were tested. The average in the young children was found to be 13.6 µg/100ml (0.66 micromoles per litre). At the same time blood levels amongst 130 children of the same age group whose parents worked in the lead smelting industry were tested. The average level in this group was 19.3 µg/100ml (0.93 micromoles per litre) - still within the safety margin, but a little elevated by comparison with the level in other children. In both groups there were a very small number of children with unsatisfactory high levels, but in every case investigation of the home environment led to adequate explanations for these levels, and it was possible to take corrective action.

5.4 In 1974 tests were again carried out on lead workers' children and in parallel on a small sample of the general population of young children in the community. On this occasion the general population level was found to be 16.8 µg/100ml (0.8 micromoles per litre) whilst that of lead workers' children was 25.6 µg/100ml (1.2 micromoles per litre). The slight upward shift in levels might be explained as a random fluctuation but in order to check that this was not a continuing trend, a repeat study was planned for 1976. Unavoidable factors did not allow a worthwhile study until 1977.

5.5 The results from this latest survey, in comparison with those previously undertaken show:

Lead Workers' Children:

1972 -	130	lead	workers'	children	- 19.7	micrograms	per	100ml	(mean)
1974 -	91	"	"	"	- 25.6	"	"	"	"
1977 -	62	"	"	"	- 18.2	"	"	"	"

Control Children:

1972 -	679	control	children	- 13.6	micrograms	per	100ml	(mean)
1974 -	64	"	"	- 16.7	"	"	"	"
1977 -	176	"	"	- 17.7	"	"	"	"

Studies of the distribution of blood levels in the population have never demonstrated any gradient associated with area of residence in Bristol and this is compatible with the findings that levels of lead in air are comparable in different parts of the City. Studies of the lead content of teeth in Bristol children show there are significantly higher levels of lead in the teeth of children

resident in the Northern part of the City, but reasons for 9*
these dental effects have not been established. Another survey to examine blood levels of the population is planned for the spring of 1979, at which time, not only will the department be employing analytical techniques similar to those previously employed in the other surveys, but it will also take the opportunity of aiding and assisting the Department of the Environment in the biological surveillance according to procedures set down by the E.E.C. 8*

5.6 Such monitoring programmes naturally involve the co-ordination of different disciplines by my department. They include the District Community Physician, the Industrial Hygienist and Medical Officer appointed by Commonwealth Smelting Limited, the Department of Health and Social Security, Department of the Environment and Avon County Scientific Services Department.

The Local Authority has co-ordinated all its heavy metal work by way of a committee termed "Bristol and District Environmental Pollution Technical Committee", which is comprised of representatives of the following organisations:

Avon County Council Scientific Adviser and Public Analyst
Department of the Environment (Central Unit on Environmental Protection)
Department of Health and Social Security
The Health and Safety Executive, Alkali and Clean Air Inspectorate
Ministry of Agriculture Fisheries and Food
Commonwealth Smelting Limited
Fisons Limited
ICI Limited
Tenneco Organics Limited
University of Bristol
ISC Chemicals Limited
Central Electricity Generating Board
Northavon District Council, Environmental Health Department
Woodspring District Council, Environmental Health Department
Health and Safety Executive, Employment Medical Advisory Service
City Council of Bristol Environmental Health Department, Medical Officer for Environmental Health and its Veterinary Adviser.

The meetings are chaired by my Chief Officer, Mr. D.J. Barnett and regular meetings take place. The group considers the results of the Bristol, Northavon and Woodspring District Councils' routine monitoring programmes, the results of the blood lead

survey in human population, blood tissue and faecal samples from animals, direct sampling of waste gases discharged from chimneys, continuous sampling of ambient air, standard deposit gauges, roadside dust surveys, soil and vegetation (including grass) surveys, and the results of the determination of fluorides in air by the limed filter paper method.

6. SPECIAL ENVIRONMENTAL MONITORING SURVEYS

6.1 The routine monitoring described so far in this paper approximates to at least 8,000 results per annum being returned for consideration by my authority. In addition to this work there are a number of one off or special surveys which my authority has either initiated or is contributing towards. In the last two years we have participated in the extention of the National Survey of air pollution by the monitoring of multi-elements and sulphate in particulate surveys conducted by Warren Spring Laboratory.

6.2 The "pilot" multi-element survey is the first National Scale Survey in the United Kingdom, of the elemental composition of the particulate material in urban atmospheres. Twenty monitoring stations were included in the network and we in Bristol operated the sole station in the South West region. Air sampling was carried out using an open-faced, downward facing Millipore cellulose membrane filter with a 0.8 μ pore size. Integrated "monthly" sampling was involved, i.e. batches of weekly filters, bulked four or five at a time. Each month the exposed filters were examined by Warren Spring, firstly by atomic absorption for lead, iron, zinc, manganese, copper and cadmium, then subsequently by emission spectrography for arsenic, beryllium, cobalt, chromium, germanium, molybdenum, nickel, antimony, titanium, vanadium. The survey lasted from July of 1976 until March of 1978 and the results are at present being computed and studied by Warren Spring. It was significant that the levels of lead, zinc, copper and cadmium determined by the multi-element sampling procedure, appeared to be of the same order as the results attained using our established continuous air monitoring techniques.

6.3 With regard to the Sulphate In Particulate Survey the 10*
problem of urban air pollution has long been associated with sulphur dioxide and smoke and these two indicators of urban pollution have been monitored extensively both in the United Kingdom and elsewhere for many years. Whilst it has been possible for epidemiologists to define levels of sulphur dioxide and smoke above which acute symptoms may be observed in patients suffering from bronchitis and other respiratory disorders, it has been realised that smoke and sulphur dioxide might not necessarily be

the specific causative agents of those health affects. Aerosol sulphuric acid arising from further oxidation of sulphur dioxide has for some time been recognised as a potentially significant agent. Animal experiments have also highlighted the effect of particulate sulphate.

6.4 The pilot survey was designed by Warren Spring to provide information on particulate sulphate concentrations and on its variation with time, location, meteorological conditions and the concentrations of smoke and sulphur dioxide. The information that has been gathered from this survey will, it is hoped, help to determine whether or not the sulphate levels found might be significant to give cause for concern. Bristol was the only station selected in the South West region out of the twenty stations strategically located throughout the United Kingdom.

6.5 Sampling was carried out employing a vacuum pump, gas meter, 8-port valve and filter papers. A measured volume of air at a controlled flow rate was drawn onto a one inch diameter Whatman No. 40 Filter Paper. By using the 8-port valve, daily samples were obtained, each sampling period commencing at midnight. Exposed filters were returned to Warren Spring Laboratory where they were analysed for sulphates by X-Ray fluorescence (XRF). In one year of the sulphate in particulate survey, in Bristol the total number of SO_4 results obtained was 161, and the range of SO_4 was from 2.4 to 23.2 $\mu g/m^3$. The spread of the results showed that 81% of the results were less than 10 $\mu g/m^3$, approximately 9% of total results were greater than 15 $\mu g/m^3$, and approximately 1% of the total results were greater than 20 $\mu g/m^3$.

6.6 Both of the pilot surveys were terminated at the end of March 1978, as it was the opinion of the Warren Spring Laboratory that the results of these surveys had demonstrated such low levels of the pollutants in question, that they considered it would be advantageous to site the instruments elsewhere in the country. This was reassuring to my staff and indeed to members of the Public Protection Committee of the City Council.

6.7 Environmental Impact Assessment - The Department has over the last four years carried out extensive environmental impact assessments, in relation to proposed new developments and existing situations. For example, the department has to date carried out three phases of environmental assessment of the 'Impact of the M32', an urban motorway which runs through established residential communities, terminating at the City Centre. The work was carried out in conjunction with the District Community Physician and the Scientific Adviser to Avon County Council. The study was designed

to assess the impact of noise and lead pollution on the environment and on residents within a 100 metres either side of the motorway, (an area including some 500 households). In order to monitor any variation in pollution as a result of the opening of the motorway, lead and noise levels were monitored in three phases - before the opening of the motorway, six months after its opening, and again the third phase, twelve months after the time of the first phase, in order to take account of any seasonal variations.

6.8 This study involved the monitoring of lead in air, dust, soil, and also the monitoring of blood lead levels in women and children living in the area. Monitoring methods used for lead in air including conventional air samplers with 0.8 μ pore size, millipore filters sampling air at a rate of 13 litres per minute, with iodine monochloride back up solutions, moss bag technique and experimental use of "TAK". The blood lead levels were incidentally considered by the Bristol and District Environmental Pollution Technical Committee at the same time (1977) as they were examining the blood lead levels of the population of the City and of those of lead process workers and their families. The mean level amongst 70 persons tested immediately before the motorway opened was 14.5 μg/100ml (0.7 micromoles per litre). The levels at six months and one year were 15.0 and 15.1 μg/100ml (0.72 and 0.73 micromoles per litre) respectively. The survey was originally intended to comprise only three phases but in the conclusions of our final report to the Public Protection Committee, it was suggested that it 11*
would be worthwhile to undertake a further phase of study as it had been shown that the lead in household dust results displayed increasing levels over the complete study period. It was considered that the increase from Phase 1 to Phase 2 could be due to weather factors, but the highly significant increase between Phase 2 and 3 results could not be accounted for. It will be interesting to ascertain whether this trend is continuing in the survey area or whether it has levelled off. It was recognised at the time of the earlier phases of the survey that, as many of the houses in the study area qualified for works under the Noise Insulation Regulations of 1975, the effective sealing of some rooms with double glazing and acoustic vent units might well have had an effect on the pattern of lead in dust deposited in homes. The lead in soil results displayed the same trend as the lead in air data, showing a large Phase 2 rise, and they also displayed a possibly significant rise between Phase 1 and 3. Again it will be interesting to repeat these investigations along with the collection of external dust to determine if lead levels are still rising in the external environment.

6.9 The fourth phase was given approval to commence by the City Council and was planned for the Spring of 1978, but due to staffing difficulties it was postponed, and is now planned to coincide with the next blood lead survey scheduled for the Spring of '79.

6.10 From time to time like many authorities, we receive
complaints that need detailed analysis. Following receipt of a
letter expressing parental concern regarding the possible adverse
effects on the health of pupils attending a primary school in
Bristol, from traffic generated air pollution and noise, an environ-
mental survey was carried out by my staff in conjunction with the
District Community Physician and the County Scientific Adviser.
We were also fortunate in having the assistance of equipment loaned
by the Ministry of Defence, Materials Quality Assurance Department.
Over a period of approximately one month monitoring of ambient lead
in air was carried out both in the internal and external environ-
ment of the school. In addition, comparative monitoring was
carried out at a control school within a half mile but not
situated adjacent to a busy urban road. Monitoring for carbon
monoxide was also carried out using both Draeger equipment, and a
Miran infra-red CO analyser coupled to a chart recorder. Blood
lead levels of 36 children attending the school were tested, and
the results compared with controls in the rest of Bristol. The
children attending the school had a range of levels comparable
with those found in other children in Bristol. 91.7% had a level
between 0-20 µg/100ml. Noise measurements were also taken, both
internally and externally at the school, using Digitronics Nomal
noise data level recorders, the results subsequently being
processed on a Wang 720C desktop computer linked to a teletype
system. The computer was programmed to produce an Alpha Numeric
Histogram giving the L_{10}, L_{50}, and L_{90} noise indices for each
hour of the analysis period. The conclusion of this total survey
during a period when weather conditions were most un- 12*
favourable in relation to the dispersal of air pollutants, was
that there was no cause for concern as far as lead and carbon
monoxide were concerned. However, the noise levels at the school
were considered to be excessive and, although the premises did
not rank for noise insulation under 1975 regulations, advice
relating to acoustic double glazing and proper acoustic ventilation
was given to Avon County Council.

6.11 Numerous other surveys have been carried out into both air pollution and noise problems in the City as part of our statutory function as enforcing Authority under the Health and Safety At Work Act. These have included the monitoring of carbon monoxide and lead in underground car parks and in the City's own transport

depots and machine shops; the monitoring of asbestos in the County Council School premises, and in the City's swimming baths; specific dust surveys, around the City and Avonmouth docks, museums, and archives, this latter work being carried out on behalf of the Authority's Personnel Department. The Authority, through its safety officer, who is responsible to the Personnel Committee, has maximised the use of the department and its equipment, to readily obtain information on unsatisfactory work areas in order that these may be rectified for the safety of all staff. More recent investigations under the Health and Safety at Work Act have included the effects on persons working with mercury in premises where we are the enforcing authority, including air sampling and blood analysis. Monitoring is also being carried out to see whether or not the microwave ovens that are found in food premises throughout the City are safe. To date over 34 separate surveys in this area have been carried out.

6.12 The Department has a continuing involvement with the work of the Avon, Gloucestershire and Somerset Environmental Monitoring Committee. This committee was set up after local government re-organisation in 1974 by the Chief Environmental Health Officers of the Districts in the County of Avon and was later extended to the Counties of Gloucestershire and Somerset. The committee is comprised of specialist environmental health officers from each of the district councils, together with scientific officers from the County Laboratories. Its terms of reference are:

1) to examine past, present and future environmental monitoring techniques
2) to advise the constitutent authorities on their statutory duties and responsibilities.
3) to co-ordinate, as far as is practicable future monitoring projects within the areas of the constituent authorities.
4) to provide a forum for the exchange of information.

This committee, of which I have had the pleasure of being chairman, co-ordinated the commencement of a survey on airborne metals in 1975. Its objectives were

a) to produce an overall picture of metallic air pollution in the three counties,
b) to highlight significant metallic air pollution,
c) to examine the data attained for correlation between three monitoring methods which were employed, air filtration, moss bag and "TAK" and to evaluate the three methods

and

d) to examine the effect of meteorological conditions on results.

6.13 Ten metals were chosen for analysis, and monitoring was carried out at 150 locations over three counties. Ten sites were chosen in each district with air filtration, moss bag and "TAK" monitoring techniques being employed at one site (the principal site). "TAK" is the proprietory name of a resin-impregnated cloth used in the decorating trade for the removal of dust from surfaces and we were interested to investigate its value in trapping and retaining particulate forms of pollution. Moss bag monitoring was carried out at the nine secondary sites in each of the districts.

6.14 More than 20,000 results were obtained in this survey which lasted over a period of twelve months. It provided valuable information to all the district authorities participating by highlighting 'hot spots' of pollution which were not previously recognised, and also qualified the ambient levels of the 10 metals monitored prevailing in the districts. This, in many districts, was the first time such pollutants had in fact been monitored. The success of the project indicated how co-ordinated professional and scientific expertise could be used by Local Authorities for the benefit of the community at large. The survey was conducted with limited financial resources. A report on the work has been 13* published. The committee is continuing its work and many of the authorities are continuing monitoring metals at some of the sites which were located as being 'hot spots' within their districts. Other surveys have been co-ordinated by the committee; the current ones include nitrates in water supplies, polychlorinated biphenyls in water courses, and lead in air in rifle ranges.

6.15 Reference was made earlier in this paper to the statutory powers that a Local Authority has to enable it to carry out direct chimney monitoring under the provisions of the Clean Air Acts. My Department has used its powers informally under the Act by carrying out flue gas sampling analysis in flues serving combustion and also non-combustion processes. This monitoring has been carried out either by way of the B.C.U.R.A. probe, or by simplified equipment involving the drawing of a known volume of flue gas through a filtering medium. This work has allowed measurements to be made of lead in flue gases from a lead melting plant, metallic dust from a metal treatment-plant, and from various melting and drossing pots used in the printing industry. The results have allowed both the City Council and industry to evaluate properly the burden of various pollutants being emitted to atmosphere which in turn has enabled correct scientific evidence to be produced in recommending suitable arrestment plant for the processes concerned. Although there are precise legal provisions regulating measurements of grit and dust, it has not

been found necessary for my department to use its statutory powers of serving a notice to require measurements to be made since all such measurements have been carried out by informal agreements with the occupiers of premises, who have readily accepted that they have a problem for which they are actively seeking advise and guidance on ways of solving.

7. NOISE MONITORING

7.1 Little reference so far in this paper has been given to the other main pollutant - Noise. I think it is sufficient to point out that District Local Authorities have the prime responsibility for the control of noise in the community, arising from domestic, industrial and constructional activities. The only area where the Local Authority are not the controlling body is in respect of certain work places where the Health and Safety Executive deal with noise exposure and its effect on human health. As far as my authority is concerned it has taken the problem of noise and vibration just as seriously as other atmospheric pollution problems. It has over the years, because of the multitude of problems associated with a large city, allocated considerable sums of capital expenditure toward monitoring equipment.

7.2 The department possesses five 'Digitronics Nomal', automatic noise data level records, with Bruel and Kjaer/General Radio microphone systems, and a Wang programmable calculator on which the cassette tapes from the noise monitoring equipment can be analysed. Programmes for a variety of different indices are available and used according to the problem being evaluated including: L_1, L_{10}, L_{50}, L_{90}, LEQ, and L.D.N. We have two C.E.L. (computer engineering) instruments, the 144, and 162, which can be used to achieve results of Spl's, Leq and in the case of the 162, L_1, L_5, L_{10}, L_{50}, L_{90}, L_{95}, period and cumulative Leq. We also have two Bruel and Kjaer, Type 2209 precision sound level meters, with 1/1 and 1/3 octave filter sets, together with vibration attachments, chart recorders, noise dose meters and various microphone and tape recording systems.

7.3 Whilst this might appear to many delegates to be a considerable amount of equipment for a Local Authority to possess I can assure you it is always fully in use. The departmental and council commitment to dealing with noise problems and the assessment of planning and housing briefs and environmental impact is considerable. The equipment used by our field officers has to be

regularly booked and, indeed, for some of the equipment (mainly the Nomals) there is sometimes a considerable waiting period. As I have indicated earlier, it is the Council's policy to maximise the equipment and staff resources to the full, with the consequence that not only do the Council's Safety Officers use our expertise in air pollution, but also in noise measurement and the assessment of risks to hearing. In addition our Engineers, Planners, and Housing Department involve EHD staff on all planning and building briefs to ensure that all buildings are correctly orientated and designed having regard to internal and external noise climates. A considerable amount of work is also done with the equipment in assessing ambient situations prior to planning and construction development and, naturally, the equipment is utilised in full, in the consideration of applications for consent under Section 61 of the Control of Pollution Act 1974.

8. WATER POLLUTION MONITORING

8.1 My authority is concerned about the water quality of the streams, water courses and dock areas, which cover a large area of the City, particularly the area of the Bristol City Dock which is adjacent to the City Centre and is not now used for commercial purposes. The intention of the City Council is to develop this area for recreational uses part of which has been achieved. It has thus become very necessary for the City Council to have detailed information relating to water quality, so that it may formulate its policies accordingly. District Councils are not however the responsible organisation for water sampling. The monitoring of water quality is strictly a statutory function of the Regional Water Authorities, in our case the Wessex Water Authority. However, the City Council feels that it does have a moral obligation in ensuring that the quality of water is as pure as possible. Thus with political backing a committee was formed in 1973 known as The Bristol Water Quality Study Group. I have been Chairman since its inception and chair regular meetings of officers from the Wessex Water Authority, the Public Health Laboratory Service, Avon County Scientific Services and the District Community Physician. We have organised collectively the various chemical and bacteriological water sampling programmes. Our work has involved other organisations, such as the University of Bristol, who have studied marine ecology. With the limited resources that are available to all of the organisations this approach has proved most beneficial to the Local Authority, for without it, it is doubtful whether such detailed monitoring

would have taken place by the Wessex Water Authority, whose priorities have naturally to be directed toward major industrial emissions, the water distribution and sewage treatment for the area.

9. ASSESSMENT OF MONITORING RESULTS

9.1 It will be appreciated that considerable time, effort and resources have been allocated to monitoring the environment in its totality by my Authority. However none of the results are to any avail unless they are properly evaluated and interpreted and used in direct policy decisions by the Authority for the benefit of the population at large. In order to allow this to occur, there has been for a number of years a multi-disciplinary assessment of pollution and its implications on health and ecology. This work is in the main carried out by the committee previously mentioned in the paper, "The Bristol and District Environmental Pollution Technical Committee", which brings together representatives of the major industries in our area, with medical, veterinary, scientific and technical experts, locally and nationally. We discuss the environmental pollution problems of the area, identify the environmental monitoring needs, and advise the relevant local authorities on the priorities and most effective methods of monitoring. We encourage uniformity of monitoring analysis, so that the results can be compared with similar work that is being carried out locally and nationally. The interpretation of the results is then, from time to time, made the subject of a report for public information, which is published through the City Council.

9.2 The work of the committee was previously directed mainly towards heavy metals. However, we are now in its second phase of development, looking at the broader issues of fluorides and oxides of nitrogen. As and when the significance of a pollutant is identified either by the companies which are producing or handling certain polluting materials, or by environmental health officers establishing facts by way of industrial survey, then the advice of our medical colleagues is sought as to the health implications and whether or not environmental monitoring should be undertaken. The water monitoring results, as I have previously indicated, are the subject of multi-disciplinary consideration through the medium of the Bristol Water Quality Study Group, and it is through that group that standards are either set or implemented if they accord with government or E.E.C. directives, and policy statements are from time to time issued to the City Council. To date both the working groups have issued five public statement in all on their work.

10. POLICIES ARISING FROM THE ASSESSMENT OF MONITORING RESULTS

10.1 Direct policies in the City Council have evolved from the assessment of pollution in the City, most of them being land use policies. In the Avonmouth locality, areas of land have been affected by the presence of heavy metals, either from the use of furnace process residuals in the past for land fill purposes or long term accumulation by fall-out from the atmosphere. This contamination has been of great importance to equine health because of the marked susceptibility of the horse to lead poisoning. The grazing habits of the horse can in certain circumstances cause a greater intake of lead on herbage than in other grazing animals. In May 1975, it was felt necessary as a precautionary measure, to prohibit the keeping of horses on publicly owned land in the immediate vicinity of lead works. It should be stressed that the important factor is the body burden in terms of daily intake of metal and the prohibition has been based assuming worst possible feeding conditions, i.e. nuitrition totally derived from grazing on inferior pastures without diet supplement from other sources. The area of designated land was published by means of press statements and the display of maps showing the area that was considerered unsuited. In view of the restrictions imposed the actual use of the land for any purposes is closely monitored by Environmental Health Officers. If for example, horses are found to be grazing on the affected land, then there is a policy that the authority will impound those horses and they have set up a horse impounding system, with all the necessary facilities.

10.2 Agricultural policies have also evolved due to the potential problem of both fluorides and heavy metal deposition on land owned by the City Council which it lets to farmers, either for grazing or for hay usage. These policies involve the imposition of various controls exercised by conditions attached to the land or crop. Reference has previously been made to the grass land surveys that are undertaken by the department - this is put into practical use by the ability to advise whether the hay crop is suitable for marketable purposes with or, without restrictions. In most cases the hay is not fit for legal sale, in view of the stringent limit for lead in animal feeding stuffs imposed by an E.E.C. Directive (10ppm on a 12% moisture basis). All applications 14*
for grazing licences and sale of crops from land now, as a policy, are processed from the City Estates, Surveyor and Valuer through the Environmental Health Department. This policy also applies to lettings/sales by The Port of Bristol Authority.

10.3 Planning policies are naturally affected by environmental monitoring results and there is as a consequence considerable

consultation between both the District and the County planners in our authority. All applications for planning permission are processed through the Department and are subject to close scrutiny to establish if there is any possible environmental pollution or noise implication. Naturally new development, by the Local Authority, is subject to the same such scrutiny. The monitoring results do affect, for example, the activites of the Bristol Industrial Development Officer. The City, like most Local Authorities, is trying to encourage industry into its area in order to promote its economic development. It is essential that all of the potential development sites, which either the City own, or which are identified as being available for industrial use are subject to scrutiny and restraints made known at an early stage to the Industrial Development Officer and the prospective purchaser or occupier. An example of such restraints are the special precautions necessary where food premises might be situated close to sources of airborne metallic pollution.

10.4 As well as the individual constraints on planning matters, the results are used for the more general purposes such as advising the County Council in the preparation of their structure plan. Many of you will be aware that the preparation of the structure plan is the responsibility of the County Councils and for that purpose they have to take into account in the preparation of land uses, all factors which might be of significance. The surfaces had to include, inter alia, geological, water, drainage and pollution considerations. The pollution map in respect of the whole of the County of Avon was prepared by each of the District Local Authorities, by way of separate maps for air pollution, noise and "other factors", the three ultimately being joined to give an environmental pollution surface which was then collated with other factors on a one kilometre grid reference system.

10.5 Policies with regard to effects of, and standards for, vegetation and animal health, have also evolved from the monitoring results of grass, ambient air, animal faeces, blood samples of liver, kidney and bone tissue of animals that have been feeding near areas of pollution. The advice from these monitoring activities is disseminated by way of the veterinary profession and the Ministry of Agriculture, Fisheries and Food to farmers.

10.6 The City's smoke control area programme has been developed on the basis of factual information obtained from the monitoring of smoke and sulphur dioxide in the atmosphere. The latter aspect of monitoring will, as already indicated, suggest to the Local Authority if it has to make provision in the future for "Special Protection Zones". So far our monitoring results show that this

will probably not be necessary in our area. However, only by continued monitoring will this fact be reappraised.

11. DISSEMINATION OF INFORMATION

11.1 How is information provided to the Public? Bristol learnt its lesson about ineffective communication in the early seventies, when insufficient and perhaps incorrect advice was given through the media regarding a lead pollution incident. This resulted in mistrust and suspicion by the public. It is, therefore, essential to build up the trust and confidence in the community of the work of the authority, and there are many ways in which this can be achieved. Information must be disseminated and understood by the communities which are affected, or who believe they are affected, by pollution problems. This can be achieved through established community groups, which can be found in most areas, particularly where issues such as pollution have focused public attention. For example, community councils and residents' associations can perform a valuable function in this respect and, it should also be emphasised that elected members of the Council have a key role to play in this. In Bristol, in addition to the reports for public information circulated from the technical committee through the City Council, information is also routed through community groups, although sometimes it is on a confidential basis. It is interesting to note that when information has been confidential, that confidentiality has always been respected.

11.2 Another approach to the communications problem has been the setting up of liaison committees with industries. In our area we now have well established liaison committees with a number of companies including the British Steel Corporation (Chemicals) Limited, Commonwealth Smelting Limited, ISC Chemicals Limited, Fisons Limited, Sevalco Limited, ICI, and Oldbury and Berkeley Nuclear Power Stations. These essentially provide the bridge between industry, the communities and the pollution enforcement agencies of the Local Authority and the Health and Safety Executive, and although they do not always find an ideal solution to everyone's problems, experience shows that mutual understanding achieved between industry and those living in the locality of each other's problems is a worthwhile objective in its own right. They are used as platforms for the industry to inform residents of the achievements which they have reached in environmental pollution control, including the capital which has been spent on its abatement, and in addition, they are able to discuss in detail the

technical problems which they encounter and show to residents the results of monitoring which they carry out. The Local Authority in a similar vein is able to provide details to the residents of all the complaints that have been made and how these have been dealt with by the authority, the Health and Safety Executive and the company concerned. We are also able to provide our air pollution monitoring reports that are submitted to the Public Protection Committee.

11.3 It is now standard procedure in the Department to submit every six months a report of our routine air pollution monitoring results which, once they have been processed through the Public Protection Committee, are placed before the City Council and therefore become a public document. No attempt is made to try and reduce either their impact, or disguise the facts, or misrepresent the results. The City Council has an extremely good liaison with the local media. All reports to committees of the City Council are sent on the day prior to the meeting to the local media for information. The media normally attend committees and take statements to supplement the reports for articles. These reports, if they relate to industry or matters of local community interest in any area, are also circulated to the industries concerned and to community groups, and to the Ward Councillors. The items are naturally sometimes raised at the local liaison committees, when officers are able to discuss in full their implications. Major documents of environmental significance such as the report on the M32 and the Avon, Gloucestershire and Somerset Environmental Monitoring Committee are made available to the Department of the Environment, the Health and Safety Executive (all Branches), the Department of Health and Social Security and professional journals. Thus, information is not only brought to local attention but is disseminated nationally and internationally if of significance. Some of the work with which we have been involved has attracted attention, not only in the United Kingdom, but from our European neighbours and we have been fortunate in the last eighteen months or so to have received delegations from the USSR, member delegations of the constituent nations of the E.E.C., France, Italy, the Republic of Ireland, South Africa and Mexico, to examine the methods of environmental management and monitoring that is carried out in the City.

11.4 As delegates will have gathered, the authority not only takes a pride in the manner in which it conducts its activities but is also concerned that it promotes proper presentation of the facts. The Committee and its officers feel, however, that they are still able to learn from others and are anxious to achieve an interchange of information and a constructive dialogue with industry. The

Public Protection Committee has, as a consequence, set up an annual meeting with members of the major chemical industries in our area, at which time such items as local liaison committees and the publication of information are discussed. An opportunity is afforded to industry to make constructive comments on how the existing systems can be improved and also make clear to the Local Authority any problems which they are encountering which could perhaps be alleviated by a change of policy of the authority. It also provides a forum for exchange on those problems which concern both Local Authority and industry alike, such as for example, the insufficiency of legislation on the transportation of hazardous substances.

12. PROJECTED AREAS FOR FUTURE WORK

12.1 It is expected that the environment will continue to be closely monitored for those substances mentioned in this paper, as being significant in the Bristol area. This will be essentially to ensure that improvements are maintained and that early warnings of any deterioration in the present position will be clearly given. To this end we have recently acquired continuous automatic monitoring apparatus, which will enable us to measure short term fluctuations in concentrations of ambient air. Earlier this year the department acquired a Technicon Air Monitor IV, a continuous colorimetric analyser with a chart recorder than can monitor, by the use of different reagents, SO_2, H_2S, ammonia, oxides of nitrogen and total oxidants. A Thermo-Electron 14D system for the detection of oxides of nitrogen in the air was also purchased, as was a Pye Unicam (Phillips) PW9755/00 System for the detection of sulphur dioxide in air. These three continuous analysers were acquired so that further research work could be carried out into the particular pollutants mentioned, all being significant in our district by way of known emissions to atmosphere. Indeed, as stated earlier the production of nitric acid in the Severnside area is the largest in the world. From the plants concerned there are discharges of oxides of nitrogen, specific emission limits being set by the Alkali Inspectorate, as they are scheduled works. However, very little is known of their concentration at ground level. Some limited research has been carried out by industry but it is of interest both to the Local Authority, to industry and to the Alkali Inspectorate, to establish precisely what levels are brought down to ground level under adverse weather conditions, which often prevail in the Severn estuary. The other pollutants mentioned all give rise, from time to time, to particular complaints in our area and are ones which need more thorough investigations.

12.2 At present field trials are being carried out into the use of this new instrumentation and members of my Monitoring and Research Section have successfully completed in-service training courses with the firms who supplied the instrumentation. Once the bench testing has been completed, then the equipment will undergo further field trials in industrial situations. This, I would comment, is being done with the full co-operation of the industries in our area, the instrumentation in some cases being placed within the curtilage of scheduled premises where there are known to be, from time to time, relevant emissions. By this method of approach the Local Authority will be able to ensure that the equipment is working correctly and the technologists in industry will themselves be able to help monitor the equipment and ensure its accuracy. In addition, security is assured. The first results naturally will be provided in confidence to the industries concerned, and these might then be discussed with the Alkali Inspectorate who await the results of the investigations with interest.

12.3 The Department has assembled a great deal of knowledge about the materials that are handled, produced and despatched from industrial premises. This information has been collated over a number of years through the voluntary co-operation of industries in our area, both in scheduled and non-scheduled works. The survey of industrial premises has, however, been more on an 'ad hoc' basis than a fully programmed area of work. The City Council feels that the time is right for an industrial survey to be carried out involving all industrial premises within the City and all materials handled, produced and transported, with particular regard to substances of medical significance. In the past, I, amongst many others, have been concerned about gaps in the system of co-ordination of monitoring results with medical statistics. However, the opportunity is at hand in Bristol in that the District Community Physician and the Area Health Authority share our desire to investigate any correlation between the materials produced or handled in our area and medical statistics of death or incidence of disease. Sir Richard Doll in his address last year to the Royal Society, pointed out that even at national level there are still many problems with regard to the interpretation of routinely gathered national statistics which are used as health indicators (such as sickness benefits, claims, hospital in-patient statistics and various morbidity registers). He suggested that these were not refined, complete or accurate enough to detect the subtle changes which have to be sought. He, and many others, consider it would be very difficult to detect locally the effects of a new pollutant unless it were to cause a fairly major problem resulting in the relatively sudden occurence of clusters of cases of easily recognised disease. This type of

occurence is rare, but was typified by the episode involving organic mercury, which occurred some years ago at Minimata, Japan, where after prolonged investigation the cause was traced to the consumption of fish caught in local waters which were contaminated by methyl mercury compounds. It is appreciated that the Employment Medical Advisory Service of the Health and Safety Executive have an overall monitoring and advisory role and the interests of employed persons are therefore well protected. A need has, however, been identified to monitor not only workers in factories handling potentially toxic materials but also persons living near those factories, both for the degree to which they are exposed to the materials and for the occurrence of unusual illness and symptoms. Harm to health is not likely to be recognised if it is not possible to demonstrate the presence of the materials in the environment. The need for reliable information on environmental pollutants has already been emphasised and therefore the City Council is to use its powers under the Control of Pollution Act to undertake and contribute towards the cost of investigation and research relevant to the problem of air pollution. The industrial survey is aimed at identifying the materials handled, the emissions to atmosphere and the by-products and waste materials which have to be disposed of.

12.4 A major secondary facet of the industrial survey is its association with major chemical emergencies. In the past 12 months my Department has had to respond to at least a dozen major chemical emergency problems outside working hours. In the first three months of 1978 there were five chemical incidents of significance which involved the Department: there was a major hydro-fluoric acid fume emission, a hydrochloric acid leak, and aluminium chloride leak, an ammonia leak from a rail tanker, and a major explosion at a fluoroaniline plant. All of these incidents occurred in the Avonmouth area. All of the premises and activities in question were scheduled under the Alkali Acts, and also were subject to control by the Health and Safety Executive, Factory and Alkali Inspectorate. However, all the incidents were considered to have an environmental significance to the population at large and the authority, whilst appreciating that the Health and Safety Executive have powers to deal with pollution if it affects the public, nonetheless takes the view that it has a moral duty to safeguard its inhabitants. As a direct consequence there is now in being a voluntary notification system employed by all major chemical companies, whereby Environmental Health Officers are alerted to any plant breakdown, leak, major emission to atmosphere. There is a standard routine that whenever the emergency services are called, and it is found or, suspected that there is a chemical and or fume problem, or anything which is of

significance environmentally to the public at large, the police will immediately call out an environmental health specialist to evaluate the problem together with the experts of the emergency services.

12.5 It is clearly recognised by the controlling authority in an emergency situation (the police), that the technical experts of the Health and Safety Executive are not normally able to respond to 'out of hours' emergency situations. Therefore, the police do have to rely very much on their own judgement whether evacuation could or might be required in emergency situations. They are clearly unhappy about this procedure and therefore arrangements have been made that expert advice will be given both by the companies' technologists, Avon County Scientific Adviser and the officers of the Environmental Health Department. For this reason it is most important that the Department's records regarding the processing and chemical operations that are taking place within its district are complete and kept up to date in readiness to respond to a situation armed with technical data which will give them the essential background knowledge of the premises and materials involved in order to make a full assessment of the implications for the surrounding environment and the personal safety of officers in attendance. Not only will the industrial survey supply this up to date technical information, but it will also allow the local authority to consider the contingency plans for emergency situations that each of the industries operate and allow the authority to plan their own emergency procedures accordingly. It should be pointed out at this stage that County and District Councils do have a responsibility by way of a Home Office directive to draw up emergency 15*
plans in the event of major disasters or emergency situations. In this context it is necessary only to consider the frightening possibility of an aircraft crashing into the industrial complex to understand why the Local Authority takes its responsibilities seriously. Contingency plans for major evacuation have to be available should the need arise. Preparations also need to be made to deal with escaped materials, the nature of which must be accurately known to take the correct course of action in directing people away from the scene. It is of value to recall that adjacent to the Avonmouth area resides a population of 20,000. The development of our industrial survey is going to have implications on other disciplines. For example we shall be seeking expert advice from the Avon County Council Scientific Services Department, the Wessex Water Authority, the Health and Safety Executive, the Fire Authority and Police. It is essential that the information be gathered and collated in a properly documented and common format

available to all emergency services. All the information gathered would be treated in a strictly confidential manner.

13. WHAT DOES THIS COST

13.1 In staffing terms, all of the routine environmental monitoring that is carried out by the Council is in the hands of a Monitoring and Research Section comprising one senior environmental health officer, one environmental health officer and two technicians. Allowing for travelling and other overhead expenses, as well as salaries and estimating one-third of the total available man hours devoted to this area of work; the total cost of employing these individual is approximately ⅓ of £27,000 resulting thus in some £9,000 for labour and overheads being applied to routine air pollution monitoring each year. To this must be added the cost of amortisation and servicing of the equipment involved and a realistic estimate is £2,500 per annum. The department are fortunate in that all analytical work is undertaken on our behalf by the Chief Scientific Adviser of Avon County Council, the cost of which is met by an annual precept on this authority. The capital cost of the equipment which we currently possess is in the order of £65,000. The current additional debt charges for such a figure are running at approximately £10,000 per annum. These figures do not, in my opinion, seem unrealistic in a Departmental budget of £1.0 million per annum. For a domestic rate payer in Bristol occupying a typical house of £170 rateable value, the rate payment represents a weekly contribution to Local Authority services of approximately 3p per week for all Public Health and Protection, Cemeteries and Crematoria services. Environmental Health costs approximately 2p per week, and our monitoring and research activity account approximately to 2% of the whole. The figure of 0.04p per week is a small contribution of the 42p per week charged for all of the City services, when one looks at the total rate payment. In addition to the City Council services costing 42p per week, Avon County Services cost £1.91 per week and the Wessex Water Authority 49p per week. Overall, the cost of both routine and special studies on atmospheric pollution carried out by my department amounts to a few pence per head of the population per annum. The value to the public is that the enforcing authorities are equipped with the necessary facts to pursue well directed policies in relation to control of emissions. In addition, it is providing a service which it is hoped will protect the public, not just in the short term but in the long term. Health, in my opinion, ranks as high as housing

or education. On the basis of the figures quoted, I think few would argue that environmental protection is demanding or receiving an undue apportionment of the available resources.

14. CONCLUSION

Environmental measurement and assessments are as fundamental to Local Authority environmental work as diagnosis is to medicine. It is necessary in the first instance to establish the nature of the existing situation, and then to use this as the basis to estimate the likely impact of changes. Follow-up measurements must, of necessity, be carried out to check what the actual impact has been, perhaps due to pollution abatement policies. The information obtained in such cases can provide useful feedback to enable policies to be coincided, as well as giving concrete evidence to the public on the effectiveness with which the responsible Authority is carrying out its duties. Monitoring can, also, have secondary uses such as checking on trends of pollutants that are not considered to be a problem at the present time, but may be in the future. In addition reference levels, which will usually consist of acceptable or desirable levels to which animals, plants or materials may be exposed, are an essential part of environmental assessment.

15. ACKNOWLEDGEMENT

I wish to acknowledge the expert advice provided by Mr. P. Cooper, Senior Environmental Health Officer, Monitoring and Research and the help of Mr. G. Evans and my colleagues in the Environmental Control Division of the Department. I am grateful to the City Council and the Public Protection Committee for allowing me to present this paper. The views and opinions expressed are those of the author and not necessarily those of the Council, and the companies mentioned.

REFERENCES

1* Royal Commission Environmental Pollution Fifth Report. Air Pollution Control An Integrated Approach. Cmnd. 6371.

2* (i) Health in Bristol. Appraisal of Air Pollution in Bristol No. 21, L.E. Robson. May/June 1973.
(ii) National Survey of Air Pollution 1961-71, Volume 2

3* (i) Proposal For Council Directive Relating to Use of Fuel Oils, With the Aim of Decreasing Sulphurous Emission. EMV/106/2/75-F.
(ii) Proposal For Council Directive Concerning Health Protection Standard For Sulphur Dioxide And Suspended Particulate Matter In Urban Atmosphere. Com. (76)48 - 19th February 1976.

4* Warren Spring Laboratory Winter Mean Contour Maps SO_2/Smoke 1972/73 and 1975/76.

5* Fuel Consumption, Smoke and SO_2 Emissions and Concentrations and Grit and Dust Deposition in the UK up to 1973/74, LR214AP and 1976, LP258.

6* (E.E.C.) Proposal For A Council Directive On Air Quality Standards For Lead, 16th April 1975.

7* A Limed-paper punched disc method of monitoring fluoride in ambient air, R.W. Wakeley, Commonwealth Smelting Limited, October 1974.

8* E.E.C. Council Direction, 29th March 1977, On Biological Screening Of The Population For Lead (77/312/EEC)

9* Lead in Children's Teeth: Day, Hart, Robinson, Nature 255:169

10* Sulphate in Particulate Survey: Report Of First Years' Results. C. McInnes LR 275 (AP) Warren Spring Laboratory.

11* An Environmental Impact Study Of An Urban Motorway - Parkway Stage II. July 1977: Day, Evans and Robson.

12* An Investigation Into The Environment of An Urban School. L.E. Robson, P. Cooper. E.H.A. April 1977.

13* Report Of The Avon Gloucestershire and Somerset Monitoring Committee On A Survey of Airborne Metals 1977.

14* The Fertilizer and Feeding Stuffs (Amendment) Regulations 1976. SI No. 840, which implement the current EEC Directives 74/63 and 76/14.

15* Ministry of Housing and Local Government Circular 76/69, Home Office Circular ES 7/1975 and Department of the Environment Circular 80/75.

NATIONAL SOCIETY FOR CLEAN AIR

45th ANNUAL CONFERENCE
2-5 OCTOBER 1978
BRIGHTON

THE ROLE OF HM ALKALI AND CLEAN AIR INSPECTORATE

by

S.J. Hart,
Formerly District Alkali Inspector,
North West

136 North Street
Brighton BN1 1RG
England

INTRODUCTION

Over the past few years, several papers by various authors, have been presented to this Conference, which have dealt very fully with the law relating to, and the general policies of, HM Alkali and Clean Air Inspectorate (ACAI). This paper discusses more fully the day-to-day work of the inspector in the field, and the ways in which ACAI is influencing development in general Air Pollution Control.

The essential function of ACAI may be defined as the provision of a specialist, technological expertise in industrial air pollution problems of special difficulty, firstly, and most important, as the statutory control body in the case of registrable works, and secondly, only on request from the responsible local authority, in an advisory capacity in the case of non-registrable works.

THE LAW

The law governing the operation of ACAI was changed with effect from 1 January 1975, when the Inspectorate became part of the Health and Safety Executive. These changes were fully described in the Chief Alkali Inspector's Annual Report for 1975(1). The principal Act now is the Health and Safety at Work etc. Act 1974, and in particular Sections 1.1.d. and 5, for the purposes of which, until such time as new Regulations are made under Section 15, the "existing relevant statutory provisions" are those of the Alkali etc. Works Regulation Act 1906, as amended to date by the Alkali etc. Works Orders 1966 and 1971, the Clean Air Acts 1956 and 1968, and the Control of Pollution Act 1974. The types of works and processes covered are thus alkali works as defined, and the scheduled works of the Alkali Act as amended. These form four groups:-

1. Chemical and Allied Industries, involving emissions of toxic or offensive gases, smoke, grit and dust.
2. Metal Industries, involving emissions of smoke, grit, dust and metallurgical fume.
3. Fuel Industries, i.e. the generation of electricity by methods other than nuclear, hydro-electric or gas turbines, the manufacture of fuel-gas from coal or oil, and coal carbonisation.
4. Other Industries, where emissions are mainly of smoke, grit and dust, and including cement production, lime and magnesia works, ceramics, caustic soda, sulphate reduction, metal recovery (scrap cable burning) and mineral works (essentially the dry processing of minerals other than coal).

The last complete lists of Scheduled Works, and of "noxious and offensive gases", were published in 1971 (2). To the former must now be added "Smelting Works" (previously registrable, but not scheduled), while, in the list of gases, "Sulphurous Anhydride except etc." should now read "Sulphur Dioxide".

THE INSPECTOR - MAN SPECIFICATION AND POWERS

Alkali Inspectors are now appointed as inspectors of the Health and Safety Executive, as provided in Section 19 of the Health and Safety at Work etc. Act 1974. This section requires that inspectors shall be "suitably qualified". The Civil Service Department's present minimum requirement is that each new entrant Alkali Inspector shall have a good honours degree in chemistry or chemical engineering, or its equivalent, or have achieved corporate membership of the Royal Institute of Chemistry, or the Instition of Chemical Engineers. Membership of the Institute of Fuel is an added advantage. A minimum of five years experience in a suitable technological industry is also required.

Alkali Inspectors, as HSE inspectors, have all the powers permitted under Sections 20 and 27 of the Health and Safety at Work etc. Act 1974, and are controlled in the disclosure of information by the provisions of Section 28.

New inspectors are trained "in the field", under the supervision of a District Inspector.

ORGANISATION

In England and Wales, the Chief Inspector works to the Director of the Health and Safety Executive, who acts as the essential link between the Inspectorate and the Secretary of State for the Environment. Headquarters staff consists of the Chief Inspector, and three Deputy Chief Inspectors, each with one Technical Assistant, ranking as an Alkali Inspector. Headquarters, also accommodates a small administrative staff, under the Chief Inspector's direction, dealing only with ACAI matters within the general framework of HSE. The country is divided into, at present, fifteen districts, each with one District Inspector and one or two Inspectors. As far as is practicable, district boundaries coincide with those of local government districts, but there are some exceptions to this. Districts are designed to give each inspector an approximately equal, but always adequate work load, and so as to provide, in each district, a sufficient variety of scheduled processes so that every inspector can develop and

exercise a wide expertise. There are also six testing teams, whose work will be mentioned later.

In Scotland, HM Industrial Pollution Inspectorate, consisting of a Chief Inspector, one Deputy Chief, two Divisional Inspectors and four Inspectors, perform the functions of ACAI in England and Wales. They are a part of the Scottish Development Department, and act as agents of the Health and Safety Executive. Northern Ireland also has its own Inspectorate, and there is a very close co-operation between the three. The remaining parts of this paper refer essentially to the work of ACAI in England and Wales, - there are some small differences in Scotland and Northern Ireland.

POLICY

Apart from the statutory limits still effective (regulating emissions of hydrochloric acid from any process, and of sulphur oxides from certain sulphuric acid plants), the statutory requirement in all cases is that the "best practicable means" (BPM) must be used to prevent the emission of "noxious and offensive" gases, and to render any discharge "harmless and inoffensive". These requirements refer, not only to the discharge stacks, but to any discharge, directly or indirectly, into the atmosphere of such gases. BPM is defined in Section 27 of the Alkali etc. Works Regulation Act 1906 as including "the provision and maintenance of appliances adequate to prevent the escape of noxious and offensive gases, the manner in which they are used, and the proper supervision by the owner of any operation in which such gases are evolved". The inspector is thus involved in the entire plant of a registrable process, its operation, maintenance and supervision.

The ACAI interpretation of BPM has been widely discussed. The principles were fully stated by Mr. Ireland, the Chief Inspector, in his Annual Report for 1973(3), and summaries of the then current requirements, with presumptive limits, were given in papers to this Conference and subsequently reprinted as appendices to the Chief Inspector's Annual Reports, by Dr. Mahler in 1966(4), and by Mr. Tunnicliffe in 1975(5). In many cases, more detailed information on current requirements and presumptive limits is given in "Notes on BPM" as published in Chief Inspector's Annual Reports until 1974, and in HSE Reports - Industrial Air Pollution since then. A full list of such Notes published to date is given in Appendix I to this paper.

These "Notes on BPM" are not Codes of Practice for the purposes of Section 16 of the Health and Safety at Work etc. Act 1974, but

are intended to guide works managements, and to provide a basis for negotiations between managements and ACAI, - flexibility is always left to meet special local conditions. All follow the same general pattern, - a preamble, standards of emission (including presumptive limits where applicable), testing, discharge conditions (height and velocity), requirements for specific parts of the plant, application to new and existing works, and general comment which always includes references to good housekeeping, available spares, and instrumental monitoring of discharges where necessary or desirable. Such "Notes" are always discussed with the Industry concerned, and their acceptance sought, but the final decision rests with the Chief Inspector.

It must be emphasised that the statuory requirement is the use of BPM to prevent emission. Air quality standards or guidelines can have no bearing, - the criterion is the lowest mass emission rate practicable in the circumstances, using known technology. Then, if the discharge is not already "harmless and inoffensive", BPM must be used to make it so. There is no legal definition of this, and a standard is used. This is that the calculated, three minute mean, maximum ground level concentration of the pollutant in air, under neutral conditions and a horizontal wind-speed of twenty feet per second, should not exceed a chosen limit. This limit may be odour threshold, or a concentration likely to damage foliage, but is most frequently the published occupational, 8-hour threshold limit value(6), divided by a factor between 30 and 60 depending upon the particular pollutant, to allow for the difference between occupational and residential exposure, and the exposure of the very young, the aged and the infirm.

IMPLEMENTATION

ACAI's control function is performed in two specific ways, prior approval and routine inspection including the measurement of emissions.

PRIOR APPROVAL

Section 9.1 of the Alkali etc. Works Regulation Act 1906 provides that no registrable work shall be carried on "unless it is certified to be registered", and Section 9.5 requires that, as a condition for registration for the first time, such work shall be "furnished with such appliances as appear to the Chief Inspector ----- to be necessary in order to enable the work to be carried on in accordance with such of the requirements of this Act as apply to the work". This condition however does not apply where a works was in existence at the time when it first became registrable. Prior

approval is thus a statutory requirement for new registrable works, and in order to ensure this most companies discuss their proposals with ACAI, and get their acceptance before committing themselves to any capital expenditure. This also applies where modifications are proposed.

Discussions, normally at District level, will involve the inspector, works management and design staff, and plant contractors. At varying stages, others such as the local government Environmental Health officer may be called in. Heads of discussion will include the process to be used, the proposed means for containing, arresting and discharging emissions, contractors' specifications, provision and stocks of spares, and consequential pollution of air, water and land likely to arise. The inspector must be able to make reliable judgements on all of these, of the additional pollution possible and its probable effects. He may require further action, or need to modify requirements to meet possible objection, but in such a way as to attain the same objective of acceptable conditions in the environs of the works. For example, in one case, where it became evident that stack height would be limited by planning considerations, a special, low presumptive limit, applicable only to that works, was devised, involving the company in the provision of additional filters. Acceptance is recorded in writing by an exchange of letters, and this then defines BPM for that particular process for the life of the plant, usually taken as about ten years. Where a process is relatively untried, ACAI may reserve the right to require additional action in case of justified complaint, and in all cases will emphasise that such acceptance refers only to requirements of the Alkali Act, and does not affect bye-law or planning consent requirements.

When erection is complete, the works will be inspected to check that it complies with the acceptance, after which the inspector will certify to Headquarters that the work is fit for registration, so that the Company's application can be met quickly, - it would be an offence for the works to commence operation before receipt of the certificate of registration.

ROUTINE INSPECTION

Routine inspection of registered works occupies the major part of an Alkali Inspector's time. The smallest, least offensive works should be inspected at least twice each year, and the more difficult ones more frequently, - eight inspections per year of a well-run "major potential offender". The more troublesome the works, the greater is the frequency of inspection. The District

Inspector himself should see every works in his District at least once in every two years.

Normally, an inspection will be made at any time during working hours, without giving prior notice, and may be by day or night. Exceptionally, in the case of an infrequently operated, intermittent process, or because the inspector needs to meet a specific manager, notice may be given. A works may be visited while shutdown, in order to check on maintenance work in hand, or closely to examine a unit not accessible while operating, e.g. an electrostatic precipitator.

Inspection covers the entire process, from the receipt of raw materials to the product leaving the works gate, wherever emissions may be expected or affected. The plant will be checked for leaks and mechanical operation, and the control panel for normality of instrument readings. Operators' log-sheets and the company's own test records will be examined, and, where appropriate, the exit sampled and tested. The criterion of satisfactory performance is compliance with the original letters of acceptance.

MEASUREMENT OF EMISSIONS

Important requirements of BPM are an accessible port in the discharge duct, through which the exit may be sampled, and regular tests by the company on such samples, records of which must be kept for the inspector. The inspector's own samples or tests are really checks on the company's own, more frequent tests.

Except in the case of particular emissions, the volume of discharge is not normally measured, - the inspector will use an agreed figure, based on design data, fan rating, or a calculation based on CO_2 meter reading and weight of fuel burned. If he is doubtful as to the validity of such a figure, he can arrange for a test-team to visit and measure the discharge volume. In general, discharge volumes do not vary much, so that if the concentration of pollutant in the discharge is within satisfactory limits, the mass emission rate will also be satisfactory.

Tests may be made on the spot by the inspector, or he may take a sample for more sophisticated analysis by a central laboratory. Tests may also be made by a test-team.

TESTS BY THE INSPECTOR are field tests on snap samples, - apparatus must be light, robust and easily portable. Emissions containing sulphur oxides, nitric acid, ammonia, hydrochloric acid,

free chlorine etc. are usually sampled with the Fletcher's aspirator, the pollutant dissolved and titrated with a suitable standard reagent. Hydrogen sulphide and arsine are checked by drawing a measured volume of the discharge through filter paper impregnated with a suitable reagent, and the stain produced compared with standards (7). Dreager tubes may be used for many pollutants, using a battery-operated aspirator where large samples are required. The most complex of these tests is that for aromatic di-isocyanates, by the Marcali method (8), as modified by ACAI (9), using the battery-operated aspirator, small but complex and very clean apparatus, very pure reagents, and a Lovibond comparator, or portable spectrophotometer. The great advantage of tests made by the inspector is the immediate availability of results.

SAMPLES FOR MORE SOPHISTICATED ANALYSIS are usually of metallurgical fume, e.g. of lead, cadmium, arsenic, antimony etc. Samples are taken in triplicate, using the Fletcher's aspirator to draw the emission gases through filter tubes packed with short staple glass fibre, supplied by the analysing laboratory, who can then allow for the appropriate blank test result. The samples are normally examined at the Occupational Medicine and Hygiene Laboratories of HSE at Cricklewood, using either the X-ray, or atomic absorption spectrograph. The inspector will try to sample when emission is heaviest, and in general one cubic foot of chimney gases is the largest sample practicable. Test methods must therefore be very sensitive, capable of detecting quantities down to 0.001 grain (6.5×10^{-5} gramme) of the pollutant. Multi-element analyses may be requested, e.g. for lead, arsenic and antimony in the emission from a lead smelting furnace recovering old battery plates. Samples of fume from the arrestors may be used to provide a guide to probable pollutants emitted. Delay in obtaining results is a disadvantage.

TEST TEAMS each consist of two men, with a van to convey heavy and complicated equipment. There are, at present, six such teams serving the fifteen Districts in England and Wales, administered from Headquarters, but with the team leader working to the District Inspector in whose District he is operating for the time being. They are principally engaged in measuring particulate emissions, especially from Mineral Works, using the BCURA method (10), according to BSS 3405:1971. Teams may also take samples as above, where isokinetic sampling is considered necessary, and do field tests where a series of results over an extended period is required, as e.g. to check variations in emission rates through a working cycle of the plant.

INFRACTION PROCEEDURE

When an inspector finds conditions which, in his opinion, constitute a breach of requirements, he will find an "infraction". If at all possible, in terms of the plant and process, he will remain on site until conditions are rectified to his satisfaction. In all cases, the infraction is confirmed to the works management in writing, quoting the conditions found, whether or not witnessed by an official of the company, the Section of the Act involved, and emphasising liability to prosecution. In general, it is found that such an Infraction Letter is sufficient action, and such conditions do not recur. If however, such conditions occur frequently, or if the infraction is considered sufficiently grave to warrant further action (e.g. where it is due to gross negligence by management), the inspector, in consultation with the Chief Inspector, may decide either to take proceedings immediately in a Court of Summary Jurisdiction, or to issue an Improvement Notice, as provided in Section 19 of the Health and Safety at Work etc. Act 1974. This notice sets out details of the conditions found, the particular Section of the Act contravened, why the inspector considers the conditions a contravention, and the action required by the company to prevent a reccurrence. A time limit is set, within which, subject to appeal, such action must be taken. If any requirement of an Improvement Notice is contravened, action can be taken either in a Court of Summary Jurisdiction, or, upon indictment, in a High Court.

ENVIRONMENTAL MONITORING

Monitoring of the air around a works is a metter normally left with the local authority, who are in a better position than ACAI to provide the daily attendance of a technologist at each station over the extended periods required to obtain meaningful results. ACAI have however, in some cases, undertaken such monitoring for special purposes, e.g. recently a 2 month survey around six major works was commissioned, to determine levels of vinyl chloride monomer, in order to check the effectiveness of BPM requirements. In some cases, e.g. organic di-isocyanates, the 3 minute mean maximum ground level concentration in air required by BPM is too low to be detected by known methods of analysis. Monitoring is then not feasible, and reliance must be placed on calculations based on stack height and mass-emission rate. Special environmental samples, e.g. of grass for fluoride pollution, are normally taken and examined by the company concerned, results being made available to the inspector, but ACAI may occasionally take check samples for examination by an independent laboratory. Several

works have undertaken their own environmental monitoring, especially some Lead, Electricity, Cement and Mineral works.

LIAISON WITH LOCAL AUTHORITIES

Close liaison with local authorities with an interest in registered works is maintained at all times. It is a duty imposed on every District Inspector that the Chief Environmental Health Officer, or his authorised representative, of each such authority shall be visited at least twice each year, for an interchange of information which can legally be disclosed - environmental monitoring results, progress with new works, complaints, breakdowns and their causes, notice of impending repair work which may temporarily increase emissions etc. Emission rates are not normally discussed - it is a duty imposed on the registered works itself, by Section 80 of the Control of Pollution Act 1974, to provide the local authority with such information as would normally be required by ACAI on this subject, if the authority serves notice that they so require, as provided in that Section.

ACAI can, and will if the local authority responsible so requests, advise Environmental Health Officers on the technological problems of air pollution by non-registered works. In the past, it has often been the frequency of such requests from several authorities which has led, in due course, to new classes of works being scheduled under the Alkali Act. Inspectors may also accept invitations to attend local government committees to discuss particular problems, e.g. the implications of BPM requirements in relation to a planning application. They have also co-operated with County Planning Authorities in the preparation of Strategic Plans.

LOCAL LIAISON COMMITTEES

In some cases, where complaint is persistent, Local Liaison Committees have been set up, consisting of ACAI, local government environmental health officers and representatives of the District Council, the general public and the various works involved. These committees, meeting three or four times a year, are not decision taking bodies, but a means of open, mutual intercommunication between the people affected and industry, on air pollution problems, with the technical officers acting as independant "friends of both parties". It has been found that such committees can not only improve relations between local residents and industry, but can also lead to better co-operation between the companies concerned.

COMPLAINTS PROCEEDURE

ACAI's attitude to complaint by members of the public is that, if such complaint arises, there must be a cause for it, but also that the true cause may not be what the complainant alleges. A classical case was a complaint of a sweet, sickly odour occurring every fine summer evening, alleged to be emitted by a near-by works manufacturing organic esters. The true cause was finally found to be night-scented stock growing in the complainant's own garden. The inspector's concern is to locate, and if practicable, to cure the true cause.

Complaint, which is most frequently due to an unforeseen failure in BPM, can be made directly to the District Inspector, whose telephone number appears, under Alkali and Clean Air Inspectorate, in the directory covering his base town. Arrangements are made, possibly by answering machine, to receive messages when no inspector is in the office. But most frequently, complaint is received through the local authority's Environmental Health Department. Unless date and time of the incident causing complaint is quoted, investigation is much more difficult.

Every effort is made to see the complaint personally, to discuss the complaint, and to obtain a full statement of his first-hand description and opinion of the conditions causing it. Investigation is then made at the works alleged to be the primary cause. If justification is found, the inspector will discuss with management ways and means of preventing a recurrence, and, if practicable, require corresponding action. If no justification is found, he will investigate other possibilities, in co-operation with the Environmental Health Officer as required. He will keep the local authority informed on progress, and will also inform the complanint, preferably by revisiting, of his findings, and the action to be taken. Personal contact with the complainant is considered to be a vital component of all complaint work

DEVELOPMENT AND RESEARCH

GROWTH OF ACAI

Over the past twenty years, the inspectorate has grown considerably in line with number of works registered, and the increasing complexity of processes involved. In 1956, before the implementation of the Beaver Committee Report, and the Alkali etc. Works Order 1958 (now consolidated into the 1966 Order), a total technical staff including headquarters of 9 inspectors covered 899

works involving 1747 processes, an average of 194 processes per inspector. In 1975, the last year for which figures have been published, a total technical staff including headquarters of 42 inspectors (plus 4 test teams) covered 2,134 works, involving 3,130 processes, - an average (excluding the test teams) of 74.5 processes per inspector. This position has been further improved since 1975. The growth of work and inspectorate is shown graphically in Appendix II.

WORKING PARTIES

1. WITHIN THE INSPECTORATE

Once in every year, all members of ACAI meet together for a 3-day conference in which progress during the past year is reviewed, and possible revisions of BPM and presumptive limits are discussed, to assist the Chief Inspector in making his decisions based on the experience of the inspectorate as a whole. In addition to this annual conference, working parties may be set up within the inspectorate to examine specific matters. These may be on an ad hoc basis, eg for detailed discussion of proposals for revision of BPM for a specific process, or on a long-term basis. Two such parties are at present examining testing methods, and the mathematical modelling of the polluting effects of multiple sources. In connection with the latter, external consultants have been given a contract to study a relatively isolated industrial area, and local authorities and industry have co-operated.

2. WITH OTHER PARTIES

Such co-operation with other parties is a continuing method of work. Thus an annual meeting is held with the Environmental Health Officers' Association for an exchange in views. Several inspectors serve on a number of Clean Air Advisory Councils, and Consultative Committees. Inspectors also frequently serve on committees of the British Standards Institution, and the International Standards Organisation. A complete list of all such committees with which ACAI have co-operated in any year is published in the Chief Inspector's Annual Report for that year.

3. WITH INDUSTRY

Over the years, ACAI have been very closely involved with industrial groups in the development of air pollution control, and working parties, frequently initiated by ACAI, nave been set up

with trade associations and their research groups, and with nationalised industries to study particular problems in order to find solutions. When such a working party has made its reccommendations, a report may be published, for the guidance of that particular industry, possibly as a code of practice, or the reccommendations may be incorporated in "Notes on BPM". Thereafter, annual meetings continue to be held, to review progress, discuss current problems and decide new policies. Reports of such working parties already published include, among others, one of the China Clay Association Atmospheric Emissions Working Party (11) dealing with presumptive limits, stack heights, storage, handling etc. of china clay, two on Iron and Steel processes, in co-operation with BSC and BISPA (12) (13), updating requirements in those industries, the Final Report of the Joint Blue Brick Air Pollution Working Party (14), giving a full account of all experimental work done to obtain control of dark smoke emissions in the firing of blue bricks, especially during the reducing part of the cycle, with the recommendation for a change to gas-firing, and the use of tertiary air as an intermediate step in the change-over, and one on the minimisation of acid-soot emissions from oil-fired brick kilns, in conjunction with the National Federation of Clay Industries (15). Many problems remain unsolved, and useful discussions continue, as for example, on the control of dark smoke from lime kilns.

In some cases, investigation of a specific problem has been undertaken by a single works. Thus, a large works, sited in a complex, steep-sided valley, and with several discharges of sulphur dioxides at differing heights, and from a number of different processes, found it impracticable fairly to assess the contribution of each discharge to overall ground-level air pollution, - a special case of the multiple exits problem. They commissioned a wind-tunnel exercise by Warren Spring Laboratory, to examine the effect of each of the major discharges in isolation, and made the results available to ACAI in duscussions on proposed new discharge stacks.

Some other projects are in hand by trade association research groups, at the request of indsutry or of ACAI. These include environmental monitoring for vinyl chloride monomer, and instrumental monitoring of lead emissions.

4. IN THE HEALTH AND SAFETY EXECUTIVE

A bonus of the inclusion of ACAI into the HSE organisation has been improved co-operation with other branches of the Executive. Thus,

Research and Laboratories Services Division is closely involved with the multiple exits exercise mentioned above. BPM for DI-isocyanates Works involved considerable discussions with both HM Factory Inspectorate, and Employment Medical Advisory Services. A matter now under discussion with EMAS, HM Mines and Quarries Inspectorate and the Safety in Mines Research Establishment is the possible, but by no means clearly demonstrated risk of respirable silica in emissions from sand-drying plants.

5. OVERSEAS

ACAI, as a long-established air pollution control agency, has received world-wide recognition, and is regularly represented on committees of international bodies dealing with air pollution, especially in Europe. The Chief Inspector has also frequently been invited to assist in developing air pollution control systems both specific and general, in developing countries, by UN World Health Organisation and the Economic and Social Commission for Asia and the Pacific, and a number of the inspectors have taken part in such work. Individual governments have also requested discussions, and have sent their representatives to this country to see ACAI in action. There is a regular interchange of information between ACAI and their counterparts abroad, especially in those Commonwealth countries which have industrial air pollution control legislation modelled on our Alkali etc. Works Regulation Act, and using the concept of BPM.

SUMMARY AND CONCLUSION

The purpose of this Conference is to consider the available ways and means for providing a cleaner atmosphere. In this matter, the essential role of the Alkali Inspectorate is to provide a specialist technological expertise in industrial air pollution control, primarily as the nation-wide, statutory controlling body for registered works, and secondly, as able to advise on problems of unregistered works when so requested by the local authority having the responsibility for control. Registrable works are scheduled because they are engaged in industries with air pollution problems of some difficulty, calling for control by technological specialists. HM Alkali and Clean Air Inspectorate is a body of men, qualified and experienced on recruitment, placed in positions where they can develop and excercise such a specialist expertise. They perform their statutory function by prior approval of equipment, and frequent inspection, involving the measurement of emissions. They are closely involved with industrial managements in the development of air pollution control systems, and with

local authorities in dealing with public reaction. They are able to discuss air pollution problems, both general and specific, with local and county authorities, and co-operate and exchange information internationally.

The basic concept on which the work of the Inspectorate is based is that the "best practicable means" must be used first to control emissions, and secondly to render such emissions as may arise "harmless and inoffensive". Practicability must take into account the current state of technology, and the cost - benefit balance. The Royal Commission on Environmental Pollution have examined this concept, and approve of it so much that they recommend that it should be extended to the control of land and water pollution by industry, to secure the "best practicable environmental option", under a unified Pollution Inspectorate (16), which would include and develop from, the Alkali Inspectorate.

REFERENCES

1. Health and Safety Report - Industrial Air Pollution 1975 pp 1-3.
2. Annual Report Alkali etc. Works, No 108 for 1971, App V, p.62.
3. Annual Report Alkali etc. Works, No 110 for 1973, pp.8 - 15
4. Annual Report Alkali etc, Works, No 103 for 1966, App V, p.51
5. Health and Safety Report - Industrial Air Pollution, 1975, App 2, p.54.
6. Threshold Limit Values for 1975 - HSE/HMFI Technical Data Note 2/75.
7. HSE/HMFI - Methods for the Detection of Toxic Substances in Air, Nos 1 & 9.
8. HSE/HMFI - Methods for the Detection of Toxic Substances in Air, No.20.
9. Health and Safety Report - Industrial Air Pollution 1975, App 3, p 65.
10. "Measurement of Solids in Flue Gases" - Hawksley, Badziok and Blackett, BCURA 1961.
11. Annual Report on Alkali etc. Works, No 111 for 1974, pp 96ff.
12. Annual Report on Alkali etc. Works, No 110 for 1973, pp 81ff.
13. Annual Report on Alkali etc. Works, No 107 for 1970, pp 54ff.
14. Annual Report on Alkali etc. Works, No 109 for 1972, pp 73ff.
15. Annual Report on Alkali etc. Works, No 105 for 1968, pp 47ff.
16. Royal Commission on Environmental Pollution, Fifth Report, p 111.

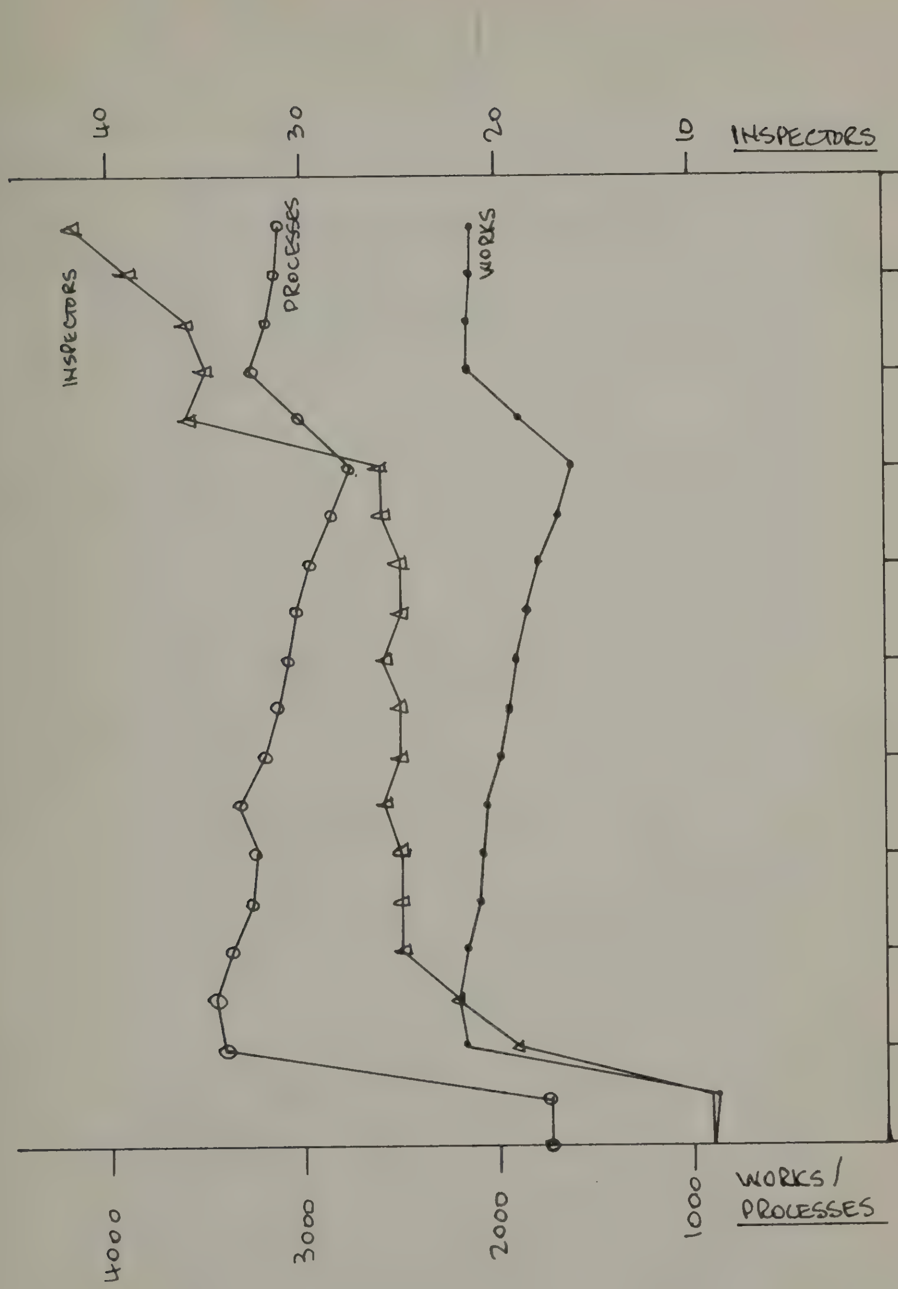
APPENDIX I

"NOTES ON BPM" PUBLISHED

CLASS OF WORK	SPECIFIC WORKS COVERED	DATE PUBLISHED
Mineral	Plaster Works	1975
Di-isocyanates	All	1975
Hydrogen Sulphide	Carbon Black Works	1975
Chemical Incineration	All	1975
Petroleum	PVC Polymer Works	1974
Lead	All	1974
Electricity	All	1974
Nitric Acid	Synthetic Nitric Acid Plants	1974
Petroleum	Crude Oil Refineries	1974
Mineral	China Clay - Report of Working Party	1974
Sulphuric Acid	Contact acid plants	1974
Iron and Steel	Hot Blast Cupolas	1974
Mineral	Roadstone Plants	1974
Iron and Steel	Notes by BSC and BISPA	1974
Hydrogen Sulphide	Chicken Feather Processing	1973
Gas and Coke	BCURA - Code of Practice for Coke Ovens	1973
Cement	All	1967
Gas and Coke	Gas Producers - Report of Working Party	1962

The following are to be published in HSE Report, Industrial Air Pollution, 1976.

Aluminium	Secondary Aluminium Works
Cement	All (Revision)
Iron and Steel	Hot Blast Cupolas (Revision)
Iron and Steel	Blast Furnaces (Revision)
Gas and Coke	Coke Works
Lime	Lime Burining Works
Bromine	All
Mineral	Sintered Aggregate Works



INSPECTORS
40
30
20
10
INSPECTORS
PROCESSES
WORKS
WORKS / PROCESSES
4000
3000
2000
1000
1956
58
60
62
64
66
68
70
72
74
76

NATIONAL SOCIETY FOR CLEAN AIR

45th ANNUAL CONFERENCE
2-5 OCTOBER 1978
BRIGHTON

THE TASKS OF INDUSTRY - MONITORING, MEASUREMENT, RESEARCH

by

H.I. Fuller,
Esso Petroleum Co. Ltd.

136 North Street
Brighton BN1 1RG
England

If asked to think of industry in the local environment, some people picture the scene at once: some dark satanic mill, the chimneys emitting black smoke - perhaps not so much as in years gone by - and a once-clear river stained with strange colours. Probably not included in this scene, however, are the goods made at the factory and the employment that lets money jingle in local pockets. We all of us make use of manufactured goods and enjoy the convenience of modern living created by industry. Despite Arcadian yearnings for 'the simple life' - which, when seen in a reconstructed Iron Age for television, looks remarkably inconvenient, muddy and cold - few of us would willingly forego our present-day comforts.

Industry exists to generate goods and services for the community- whether the products are the necessities of life like food and drink and a roof over our heads, or are more optional like trains, books and television programmes. We all like to enjoy these products but we generally don't want industry as a neighbour over the fence. Who likes a canning factory next door? or a steel-works? or even a printing press turning off next morning's edition in the middle of the night? So we try to zone the more obtrusive industrial activities away from housing areas, with varying degrees of success.

Since we need the goods created by industry and factories have to be somewhere real, it becomes essential for industry to be at least acceptable in the local environment. The trouble is that all activities - and not just industrial ones - potentially create a pressure on the local environment; even domestic refuse stinks if left around. Because we can't make our "omelette' of goods and services without breaking industrial eggs, the question is: "what are we going to do about the eggshells"? We need to evaluate the problems and make proper arrangements.

EVALUATING THE NEED FOR ACTION

A natural first reaction to an industrial situation is to say there shouldn't be any emissions if the factory is properly controlled. Although this has to be done for certain really hazardous materials, it takes an enormous investment to install the necessary facilities, and further effort to make sure they work and continue to do so reliably. For more everyday emissions, such as from fuel combustion in industry or the home, the effort needed to contain all the possible pollutants would be out of all proportion to the degree of hazard involved. Moreover, all this effort costs money which ultimately must be reflected in the cost of the goods or services being produced. There is a fine

political philosophy which says "the polluter shall pay" and it is right that he should have to make the investment but, of course, it is the community at large which in the end pays for pollution control either in more expensive goods or in fewer of them. Clearly, a balance has to be struck between the value of the 'goods' that society wants from industrial activity and the value that society puts on its environment.

Since controls cost money, it should not be too surprising that industry always wants to take a good look at the need for action. To do otherwise would be irresponsible. Although it may sound reactionary, industry cannot be expected to act in response to mere speculation - which is often merely an emotional, unfounded apprehension that whatever it is that is being emitted must be doing harm, somewhere. Speculation is not a firm enough foundation on which to base expenditures which may run into millions of pounds of investment.

Before spending money, a works must have reasonable evidence that an unacceptable situation exists or will probably develop unless something is done. Moreover, for a pollutant that could come from several sources in the area, there must be good grounds for believing that the works in question is itself a significant contributor. For instance, it is unrealistic to be unduly concerned about particulate emissions from an oil-fired industrial boiler in an area noted for, say, quarrying or a cement plant.

Ideally, a works should always try to be aware of its emissions of potential pollutants, but this is much easier said than done. Because of the virtually endless range of candidate substances, such an aim would present not only very great analytical problems but it would also be continually changing as new medical knowledge modified attitudes about present emissions and revealed new reasons for concern about others. To keep in touch with these changing requirements is hard enough for large organisations; it is particularly difficult for small organisations that don't have the necessary skilled staff at all. However, all industrial organisations need to recognise they have a responsibility for making a positive contribution. Any works should be ready to reconsider its situation if increased throughput might contribute more of a pollutant to the area. Particularly when a factory is installing a new process or making a new product is it essential for it to review the possible problems.

Evaluating the potential impact of emissions on the local environment takes many skills, for the situation is rarely simple. There have to be measurements of emissions or of ground level concent-

rations, there have to be calculations (possibly involving computers), and there have to be discussions with experts in many fields - obviously with meteorologists and chemists but more particularly with those well qualified to evaluate environmental health hazards.

Measurements of air quality or emissions have to be made with special instruments. As smaller concentrations of pollutants become of concern, these instruments become more and more sophisticated and require highly specialised staff to operate them. It is, of course, necessary to take representative samples - and other specialists will then argue that the samples weren't representative of the emissions or of the population exposed to them! Sometimes an industrial company is competent to handle these problems for itself; more often, industry seeks the advice of consultants who specialise in the problem areas.

Whatever the expertise, however, it is unwise to rely solely on instruments and theoretical calculations. Although desk-top analysis is much more congenial, long experience has taught environmentalists to go and look - to use eyes, ears and nose to see how things actually are in the local environment, to observe how a chimney plume sometimes dips over water or curls over a hill, to recognise a valley where mist and pollution may hang about, to see that a belt of trees shields a housing estate from noise.

In the final analysis, the industrial environmentalist has to compare his findings against targets or regulatory limits. In co-operation with central and local authorities, he will want to assess how well his factory stacks up against agreed guidelines, and, since pollution levels can fluctuate with the weather, what is the probability that the acceptable levels will be transgressed and how often? To be done soundly, these assesments demand accurate measurements made over a long period of time. Too often, however, it is in the nature of things that one is faced with making a judgement on half-an-hour's data taken on the only fine afternoon in months!

SCOPE FOR ACTION

Given agreement that action is needed, the next step is to find out what can be done. This involves consultation with engineering and technical experts, both within the plant and outside, to review the available technology; modify the process? adjust the conditions of the operation? maybe absorb the offending material, without creating another waste disposal problem. It is the proper responsibility of a works to have this information or to obtain it

from elsewhere if it does not. Some organisations are big enough to undertake their own research to solve an emission control problem; others rely on consultant engineering firms or trade associations. But is must not be assumed that all problems can be resolved merely be putting a big enough task force on the job. Some problems - controlling disagreeable odours, for example - continue to present technical difficulties despite the application of many years of engineering and chemical skills all over the world.

In considering the alternatives, industry must have regard for economics, seeking out cost-effective technology within the resources of money, effort and materials that are available. Since it is industry's proper role to supply goods and services, there is no social benefit in a works that takes on such a great economic burden that it has to close, later if not sooner. In the USA, regulations requiring the use of 'Best Available Technology' have become so stringent that continuation of some industrial activities is threatened. Already, to meet earlier legislated requirements, many foundries there have had to be closed, with evident implications for the economic well-being of the region or even the country. In the UK, we are right to be proud of our tradition of 'Best Practicable Means' for this allows for the improvement of an unacceptable situation by gradual degrees rather than by the imposition of revolutionary and draconian requirements. Evolution provides for progress within the economic viability of a works, making room for further improvement as new funds and new techniques become available. The Alkali Inspectorate has been likened to a ratchet - all take and no give - but this policy of gradual improvement allows the patient to survive where an all-or-nothing operation would kill.

Industry is justifiably wary of revolutionary controls for a further reason. Experience - which some might call bitter experience-has sometimes shown that what may be this year's miracle technology for pollution control is next year's technological failure. Too often, an insufficiently tested process, hastily rushed through its small-scale proving stages to meet a politically inspired deadline, has failed to match its performace in real life - through unforeseen scaling of pipes, poor heat transfer, reduced yields, and so on. The decision to install equipment for emission control irrevocably commits money, manpower and materials, and construction and commissioning take irreplaceable time. A wrong political decision may be merely embarrassing; a wrong investment decision involves irrecoverable resources. Such disasters - for they are disasters in that their costs must inevitably be reflected in the economic buoyancy of the works - are best avoided by open discussions between authorities and industry, by a

willingness to avoid rigid attitudes, by reasonableness.

MONITORING THE PEACE

Once action has been taken, equipment installed, processes modified, it is natural to want to assess the improvements achieved. If the works is the principal or sole source of the offending emissions in the area, and if it has the necessary pollution monitoring equipment and skills, it is reasonable for it to take the measurements and to analyse the data. However, if there are many sources in the area - and especially if domestic sources also contribute to the pollution - the Local Authority is the proper body to undertake the work, possibly with assistance from works that are involved and that have the necessary technical capability. While industry can usually set up a measuring site on its own property, the results will obviously be more limited than measurements made over a wider area. Here Local Authorities are better placed to find suitable sites under their own control, where services are available and security can more easily be maintained. Again, co-operation between industry and authorities monitoring may be practicable.

Air pollution monitoring is remarkable for the quantity of data that is very quickly generated. Undigested, such data are meaningless. Interpretation requires many skills, not least an understanding of statistics so that the frequency with which the higher pollution concentrations occur can be properly assessed against mere chance occurrence. The situation must then be considered in the light of where and when and in what circumstances these higher concentrations occurred - which requires detailed local knowledge of geography and of weather. Finally, before any monitoring results and their interpretation are published they should be critically reviewed to see if the conclusions stand up to common sense. An example comes to mind: measurements taken at a site not far from a works suspected of causing pollution were indeed higher than average, but a site visit showed that owners of adjoining allotments often lit bonfires - with obvious effects on the monitors. It is important to remember that the most obvious source may not be the most important.

The Control of Pollution Act, Part IV, encourages the dissemination of information through local groups, which should comprise representatives of the Local Authority, of industry, and other local experts. Some groups of this kind have already been set up under this legislation; others have existed informally for many

years in areas where there has been public concern about a particular industrial activity. Circular 2/77 gives sound advice about the formation of such groups. Industrial organisations should play a positive role where the Local Authority sees the need to set up a group but is would be presumptuous for industry to take the initiative. On the other hand, many works already invite interested groups - such as a ratepayers' association or the local branch of the Association of Environmental Health Officers - to visit them from time to time, especially if there seems to be a specific problem to discuss.

How should a works judge the success of its environmental conservation efforts? One of the more effective means - even if contradictory at first sight - is to monitor the level of complaints made about the works; in particular the works should be very aware of what is being said in the local paper or at the local Council meeting. This activity should be seen as a proper part of the monitoring programme, which should be concerned not only with what may affect public health or plants and trees, but also with what upsets people.

However, if complaints are to be of practical value in leading to an effective remedy, they must be timely. The public should have the opportunity of making a prompt response, for instance about an unpleasant smell; if left until the next day, the source may well be untraceable. For this reason, one oil refinery has found it useful to list one of its telephone numbers under 'Complaints'.

Naturally, a more responsive company may well receive more complaints than a works next door which maintains a 'brick wall' attitude. However, if complaints are answered properly, the company can judge its real success in controlling its potential to pollute from the number of complaints that continue to rankle and which are pressed with the Local Authority or MP.

All monitoring is a matter of awareness, by a works for the potential consequences of its actions, by a Local Authority for the significance of one source in comparison with the various alternative sources that may be a cause of pollution. Co-operation in measurement and interpretation makes sense technically, economically and politically.

CONCLUSIONS

Since industrial activities - like all human activities - carry

the potential for pollution, every factory must accept that it has a social responsibility to weigh what it is doing to its environment. Using either its own skilled manpower or the advice of expert advisers - consultants and/or Local Authority - it should endeavour to keep in touch with current opinions, take steps to estimate the impact of its emissions of the recognised pollutants, and aim to control these emissions if accepted criteria are exceeded.

However, industry's critics, many of whom would apparently like to get back to a supposed paradise of pastoral self-sufficiency, must accept that, for the great majority of our population, industrial activity is the only way of providing the basis for a reasonable life. For these benefits, the community has to accept some degree of environmental risk, seeking to achieve a balance of control that is best summarised as 'Best Practicable Means', where the benefits in environmental conservation are in step with the costs of achieving and maintaining them.

Industry exists to provide goods and services needed by the community. It also provides employment. Industry must have one over-riding principle: it must not operate at a loss and go out of business, for a derelict factory is the ultimate degree of local pollution. Like any other member of the community, therefore, the proper role of industry in the local environment is to be a good neighbour and to stay alive.

NATIONAL SOCIETY FOR CLEAN AIR

45th ANNUAL CONFERENCE
2-5 OCTOBER 1978
BRIGHTON

THE NEED FOR EDUCATION - ARE WE DOING ENOUGH?

by

D.J. Lewis,
Keep Britain Tidy Group

136 North Street
Brighton BN1 1RG
England

INTRODUCTION

Before proceeding with the consideration of the main theme of this paper which is based on research into the production of the 'Keep Britain Tidy Group school programme undertaken by Cherry Mares at the Brighton Polytechnic, it is worth outlining the role of the Group which is under the Patronage of H.M. Queen Elizabeth the Queen Mother and is recognised by the Department of the Environment as the national agency for litter prevention. It is responsible for educating the public in litter awareness and for winning maximum public participation in litter abatement.

One way of winning public participation is to enforce legislation by punishing offenders under various Acts such as:-
Litter Acts, 1958 and 1971, Civic Amenities Act, 1967,
Highway Act, 1959, Vagrancy Act, 1824, Public Health Act, 1936,
Public Health Act, 1961 and Caravan Sites Act, 1968.

It is difficult to increase the intensity of enforcement because the majority of the electorate do not consider littering a serious enough offence to warrant the attention of the Courts. However, a limited number of successful prosecutions of blatant or persistent offenders would create publicity and bring the matter to public notice and in this way form part of the process of education and persuasion.

On the question of Draconian measures it is interesting that none of the 32 member countries in Clean World International considers that enforcement through penal sanctions is the answer.

In the difficult and inevitable long term programme of public involvement we had better start off with the internationally agreed definition of litter "any rubbish in the wrong place". Obviously if rubbish is in a rubbish container, it is in the right place, forms part of the waste management cycle and cannot be classified as litter.

Litter abatement is therefore the first step in solving the problem of waste management and indeed the first step on the environmental ladder of responsible and constructive care of resources.

The solution is to stop people littering - to stop them being anarchists - for in simple terms it is people who make litter and only people can stop litter. We must contrive to change attitudes, and, even more difficult, to change behaviour patterns which are deeply ingrained in us all.

These behaviour patterns have become accepted norms. It is, for instance, considered normal to drop rubbish on the floor of a compartment in a train because no receptacle is provided. One of the first tasks therefore is to determine what unwritten rules and accepted norms apply in regard to littering in any given situation.

In order to win public support in preventing litter, it is necessary to define the main sources of litter for unless these are tackled no systematic attack can be undertaken. For example there is nothing more calculated to frustrate even the most conscientious citizen than an overflowing street litter bin. What incentive is there to keep a street tidy if it is degraded by inefficient or defective services? We know from practical experience that tidiness encourages tidiness and vice versa.

What are the main sources of litter? They are mishandled household waste, improper commercial put-outs on pavements and yards, construction and demolition works, sloppy loading, carriage and unloading of goods on vehicles and of course pedestrians and motorists who account for less than one third of litter in public places.

When we examine sources of litter we also need to understand the dynamics of litter, what it consists of, where it comes from, how it moves and how it becomes trapped.

Because we are all involved in creating the problem we must all be involved in the solution. We will never get on top by pretending that to spend more on cleansing will eventually produce the cure.

As campaigners we have to win the support of everyone in the community. We must get the message across to them directly as individuals and also through the widest range of associations from the family group, through voluntary and professional associations, political parties, sporting affiliations and of course the Churches.

Making a comprehensive plan to change people's normal behaviour in the handling of waste would involve four components:

a) A continuing review of Local Authority working practices.
b) The improvement of technology in the Local Authority and in the industrial sector.
c) The creation and maintenance of effective public information and education services.
d) The enforcement of penalties on blatant litterers and persistent offenders so as to make public examples of them.

In this session we are concerned with the aspects of enforcement and of education. It is our view that developing information and persuasion services will win public support and involve the participation of the community.

Fining litterers will require a favourable climate of public opinion which can be created by successful public participation and education. It will also require the will of the Local Authority and of the Police and the blessing of the magistracy.

Prevention is surely better than using expensive and wasteful control measures but educating the people will require a programme of mass communication. The aim would be to reach as many people as possible. One of the techniques used is called the "Peer Group Philosophy". Briefly, this consists of using popular key or respected public figures to impart the message. The Keep Britain Tidy Group successfully uses Disney and Womble characters, pop groups, actors, television and sports stars and so on.

Educating individuals will mean that they will carry their litter consciousness into their working lives and into their religious, social and sporting associations which are encouraged to include litter abatement in their own general activities, for example, the Women's Institutes, the Guides, the Scouts and so on.

The first aim is to create an awareness of litter. The second is to stress the fact that litter is socially unacceptable and that everyone is an actual or potential litterer. We need to emphasise that litter is illegal, dangerous, costly, unsightly and damaging to the quality of life.

Testing the results of the education campaign

It may well be asked whether there is any hope of eliminating the problem in the long term. We believe it can be done, for we can recall that within the lifetime of most adults the filthy, dangerous and anti-social habit of spitting in public places has practically ceased.

When the Group's current level of programme activity commenced in August 1972, an independent survey was made of litter found at 50 typical nationwide sites. Five years later in strictly comparable conditions a similar survey revealed that litter found at these sites had fallen by 37%. We would not wish to read too much into this information but we do find it encouraging that in general our littering habits appear to have improved over a period which matches in time our new programme of activity.

This improvement was in no way due to the enforcement of legislation which maintained a low level of some 3,500 successful prosecutions each year. The weight of fines imposed was derisory.

Schools

When we planned our new programme in 1972 we were concerned that the acceptance of litter abatement as a subject in the schools should be encouraged. We hoped to achieve this by obtaining the positive involvement and support of education and other interested authorities as well as of teachers and of course of the children themselves. It was for this reason that, in 1973, Brighton Polytechnic was invited to undertake research on our behalf, which under Cherry Mares has led to the successful production of learning kits for use by teachers in primary schools.

Education: the key

As a mark of the Group's firm belief in the value of education, the research at Brighton Polytechnic is continuing as an ongoing and permanent feature of our programme with the aim of providing materials and methodology for teaching school children of all ages and of monitoring and when appropriate updating the current programme.

NATIONAL SOCIETY FOR CLEAN AIR

45th ANNUAL CONFERENCE
2-5 OCTOBER 1978
BRIGHTON

RESEARCH INTO METHODS OF INCREASING CHILDREN'S AWARENESS OF LITTER AND SENSE OF RESPONSIBILITY FOR THEIR ENVIRONMENT

by

Cherry Mares,
Keep Britain Tidy Group

136 North Street
Brighton BN1 1RG
England

Aim of the research

The aim of the research is to find ways of increasing children's awareness of litter and responsibility for the environment.

"Awareness of litter" was not defined precisely during the first stage of the research, but is was accepted that the expected outcome of the research was to find ways of making children concerned about litter pollution and conscious of their role in litter prevention. Litter pollution is one aspect of environmental pollution and it seemed appropriate that any attempt to increase children's awareness of litter should take place in the wider context of responsibility, awareness and concern about the environment. There is, of course, an immediate connection between the problems of litter and air pollution as they are both aspects of environmental pollution.

It is not easy to give children, and particularly young children, an understanding of the inter-relatedness and enormity of environmental problems and of their personal responsibility for the reduction of these problems, without at some time making them feel overwhelmed by the size and complexity of the problems and by inference, by their own inadequacy in dealing with them. However, the particular problem of litter is something which can be prevented or controlled by individual or small group effort. It was therefore proposed to take the problem of litter in the children's immediate environment as a practical exemplar - to examine in depth its nature, cause, effect and possible solution and to use this as a starting point for an introduction to a study of wider environmental issues. It is suggested that helping children to experience, comprehend and be concerned about one particular environmental problem, whether this is litter, water pollution or air pollution, may well be the means of helping them to be concerned and aware of other problems and of giving them some understanding of the role and responsibility of the individual in the improvement of the environment.

Preliminary investigation

The research began with a period of preliminary investigation and surveys in schools, local authorities, environmental organisations and briefly, in some other countries to establish relevant strategies in current use. As a result of these investigations, certain principles were identified which were thought to be fundamental to the design of the proposed learning experience and materials. These principles were that

- The learning experience should ideally be long term, interdisciplinary and curriculum-related, giving practical experience of environmental problems, making use of the environment as a resource for learning and involving pupils and schools with the community.

- The learning materials should be supportive, flexible, informative, audio-visual and of high quality.

Reasons for selecting Primary Schools for the pilot study

Although in the long term this research is seen as being part of an educational development which will eventually extend across the school curriculum, involving children from four-plus to eighteen, the construction and testing of innovatory materials at more than one level of the educational system was beyond the scope of the initial investigation and it was necessary to select one age group for whom materials could be constructed and with whom evaluation could take place.

For several reasons, primary schools were selected as being the most appropriate area for the detailed pilot study. Many primary schools work through interdisciplinary studies which give the breadth of experience considered necessary for education for environmental responsibility. The child-centred learning, discovery approach and project work fundamental to the majority of progressive primary schools, provide the practical experience, personal involvement, opportunity to use the environment as a resource for learning and involvement of the local community, emphasised in the initial survey. Most primary schools also have few restrictions imposed by syllabuses and, with flexible timetables and the class teaching system, teachers have the opportunity to examine children's reactions to a learning situation in considerable detail.

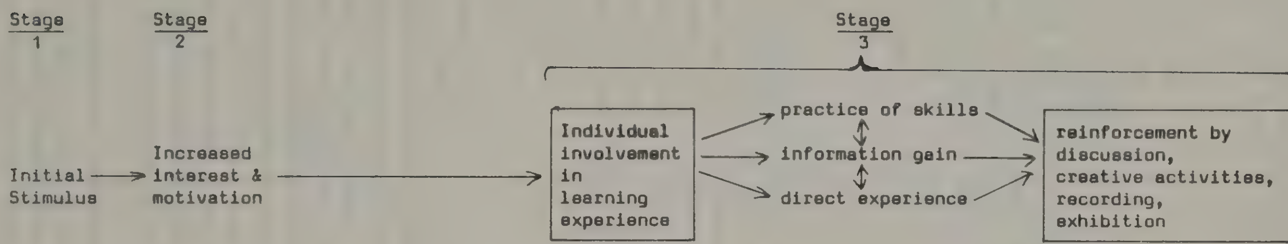
Because of the nature of primary school education and the fact that many children in primary schools work through projects, it was decided to produce a fully supportive learning kit. This would act as stimulus and support for a project based on the subject of litter and lead on to wider environmental issues.

The strategy for the project is illustrated below in fig. 1/fig. 2

The experimental learning materials

Teachers were given the experimental materials during the spring term and asked to start using them with their classes at the be-

Fig. 1 Proposed strategy for primary school teaching and learning project



This strategy was worked out in terms of a multi-media kit.

Fig. 2

Stage 1	Stage 2	Stage 3
film →	slides →	A. workcards
35mm	38	B. support materials, posters, protective plastic materials, reference books/fact sheets, teacher's notes.
10 mins.		

ginning of the summer term and to continue using them for as long as their own interest and that of their pupils was sustained. The materials consisted of film, slides, workcards, teachers's notes and posters.

a) Film

The film was used to introduce the project, arouse interest in the subject of litter, give some indication of the extent of the problem and stimulate discussion. The limited time and money available precluded the possibility of making a special film and it was necessary to select from films already available. The most suitable of these was an eight minute Walt Disney cartoon which shows a variety of anti-social littering habits and emphasises the contribution made by individuals to environmental quality.

b) Slides

Thirty-eight slides were used to reinforce the interest aroused by the film and form a link between this interest and later assignments. They were also intended to provide a basis of structured information, motivation for enquiry and activity and stimulus for discussion.

The slides concentrated on three main aspects of litter - litter as an eyesore; the organisation of litter and refuse collection and disposal; litter as a danger to humans and animals.

c) Workcards

The general aim of the thirty-eight workcards was to harness the children's initial interest and motivate them towards a variety of directed activities and experiences related to the central theme of litter and leading on to topics of wider environmental interests. More specifically the workcards were intended to give the children the opportunity to cover the areas of enquiry and activities necessary to achieve the objectives of acquiring skills, attitudes and information, and to encourage children to practise the basic skills, to explore, observe, experiment, question, create, discuss, order and record their findings in a variety of ways.

Activities likely to contribute to the change in both the cognitive and affective components of attitudes were included. For example, group discussion supporting a particularly positive viewpoint about behaviour was encouraged as was the opportunity to experience pleasure from being actively engaged

in environmental improvement. The obtaining and dissemination of information, role-playing and interviewing were also encouraged.

The activities on the workcards were planned to conform to the principles already mentioned. They were long term in that ideally the activities would continue for the whole of the academic term, providing ample opportunity for topics to be studied in depth. They were curriculum-related and inter-disciplinary, and encouraged activities in as many subject and overlapping curricular areas as possible, for instance in history, geography, biology, maths, science, art, drama, movement and English and involved a variety of creative and imaginative work as well as general research.

The workcards were also intended to help in exploring all possibilities for practical experience and activities, using the environment as a resource for learning and taking every opportunity for involving the rest of the school, family and the community outside the school.

The workcards were supportive and, as far as possible, self-explanatory. They gave explicit instructions about how to record work, how to prepare for and clear up after experiments and practical work, and also suggested further activities which might be developed.

It is perhaps useful to consider these somewhat stark statements in terms of what actually happened in the classroom. After seeing the film and slides, and joining in discussion which related these visual stimuli to their own experience and local environment, the children took part in a survey of the litter bins, picking up and mapping litter in the school corridors, playgrounds and perimeters. They sorted the litter into sets of, for example, paper, card, wood, plastic and glass, calculated the area, volume and weight of the different sets and recorded their findings in graphs. They carried out simple experiments to test the bio-degradability of the various kinds of litter. After this practical work, they made more general surveys of the local environment, noting not only litter, but general environmental quality and talked to the people whose work was directly concerned with environmental quality, for instance cleansing staff and town planners. They made studies of depletion and recycling. They looked at the effect of litter and pollution on wild life. They made up stories and plays and gave talks, produced collages and models, designed equipment, invented imaginary monsters; made up songs

and music, and found out about the historical background to cleansing. In fact the project on litter developed into a lively and far-reaching examination of a multitude of topics related to the environment

The evaluation

The evaluation was based on questionnaires completed by teachers and children, on observations in the classroom, reports written by teachers and observers, discussions with teachers and children and on the results of a series of tests (for awareness, readiness to express concern and for information gain) administered to the children.

The aims of the evaluation, related to the data required to achieve these aims, the source of the data and the means of gathering it are given below, fig. 3.

The design of questionnaires and the use of observation, interviews and tests for information gain are straightforward evaluation procedures and presented no particular problems. However, no test instruments suitable for an assessment of children's awareness of litter were found in the time available for literature search and consultation, and the measures were constructed by the researcher. It may be of interest here to give further details of one of the tests for awareness.

Test for awareness of litter

It seemed likely that if a test were devised in which children were given the opportunity to comment on the presence/absence of litter without being specifically instructed to do so, then only those children who were "aware" of litter would comment on it. The problem was therefore to devise a situation in which, given suitable stimulus, children would verbalise about their awareness or consciousness of the presence or absence of litter. It was essential that the tests should be sufficiently subtle so that their purpose and affiliation would be concealed from the children, but simple enough to be carried out adequately by children of a wide ability range.

Bearing these constraints in mind, a test was devised in which children were shown a sequence of three coloured slides depicting a lakeside, a beach and a railway station. Litter was not visible in the first slide; just discernable in the second slide and clearly visible in the third slide.

fig. 3

Aims of evaluation	Data reqd. to achieve aims of the evaluation	Means of gathering data	Source of information
Assess the effectiveness of the learning materials in providing stimulus and support for a satisfactory learning experience integrating a wide range of curriculum activities.	Teacher's reports on materials and on children's reactions	QUESTIONNAIRE + open-ended reports, + interviews and discussions	TEACHER
Identify ways in which the materials could be modified to improve both their effectiveness and the quality of the learning experience	Children's own reactions to the materials and learning situation	QUESTIONNAIRE + interviews, observation and discussions	CHILDREN
Assess whether children using the materials had greater awareness of litter and greater information about certain properties of litter than children who had not used the materials.	Assessment of children's awareness of litter	TEST scores	CHILDREN
	Assessment of children's information about certain properties of litter	TEST scores	CHILDREN

Each slide was exposed in turn for fifteen seconds and the children were then given four minutes to write about it before being shown the next slide.

A standardised system of marking was devised so that the children could be graded on a three-point scale of not aware, aware, very aware.

The experimental group made a total of 419 "very aware" responses as compared with 48 "very aware" responses of the control group. The scores of the experimental group (significant at the 0.1% level) indicated that these children consistently showed more awareness of litter than the children in the control group. It is suggested that the learning situation was a major factor contributing to the difference between the two sets of results.

The reactions of the experimental group are of particular interest in that many of these children made very critical statements about littering behaviour, although when writing about the first slide (where no litter was visible), their comments were elicited without obvious stimulus. For example when writing about the lakeside, many children suggested that when the picnickers seen in the slide had left the area, it was likely that they would leave litter behind. They also commented unfavourably on the thoughtless and irresponsible attitude that resulted in littering behaviour and on the individual's responsibility to improve rather than pollute his environment. None of the control group made comments such as these.

Findings of the evaluation

The main findings of the evaluation were that:-

a) The subject of litter was a suitable starting point for projects which, in many cases, developed as studies of wider environmental issues, with the learning materials acting as a stimulus and support for a satisfactory learning experience.

b) The majority of the children enjoyed the learning experience, particularly the practical nature of many of the activities and the opportunity to make visits outside the school and discuss their work with adults in the community. They also appreciated the practical relevance of the topics studied.

c) Children who had used the learning materials were significantly more aware of litter and had significantly more information about litter than children who had not used the learning materials.

d) Teachers commented that children who used the learning materials became noticeably more concerned about litter and less liable to drop litter in or out of school.

"Litter: an environmental project"

Using information gained during the evaluation, the experimental learning materials were redesigned. Certain changes were made, particularly as regards the provision of materials more appropriate to less able children.

The redesigned materials form a kit "Litter: and environmental project 10/11". The kit consists of a teacher's handbook, a thirty-eight frame film strip, fifty-eight workcards (thirty-eight for average class use and twenty for less able children) and three wallcharts. The materials have also been adapted for younger children and are available as "Litter: an environmental project 7 - 9".

Current Research

The first stage of the Keep Britain Tidy Group Schools Research Project ended with the production of the two kits, but the study and evaluation of these materials is an on-going process. So far over 4,000 kits have been supplied to primary, middle and special schools in this country and abroad.

Contact is maintained with selected teachers using the materials, with study groups in teachers' centres and colleges of education and with research projects with similar aims. This constant feedback will ensure that modifications necessitated by changes in teaching methods, legislation, littering behaviour, or availability of resources can be incorporated into successive reprints.

Considerable interest in the materials has been shown in other countries (in Europe, North America, Australia, India, Hong Kong, Singapore). The 10-11 kit has been translated into Welsh and German. The West German government has supplied the kit to all their primary schools. Discussions are taking place in Brussels about the possibility of translating and adapting the materials and evaluating their effectiveness in several common market countries and pilot studies are being set up in both France and Belgium.

As a second stage of the research, work has started on the production and evaluation of curriculum-related learning materials to encourage awareness of litter and environmental responsibility in pupils in infant and secondary schools.

Further research

Several areas have been identified which could usefully be studied, in particular, the comparison of the effectiveness of different methods of forming responsible attitudes towards the environment. One of the assumptions of the present study was that giving children practical experience of the litter problem is of importance, but it has not been established whether or not this practical experience increases awareness more effectively than a theoretical knowledge of the litter problem.

A further fruitful area for research would be an investigation of the possible relationship between awareness and behaviour in order to establish whether children rated as "very aware" of litter are any less likely to drop litter than children rated as "unaware". It would also be interesting to investigate the suggested possible relationships between awareness of litter and such factors as sex, I.Q. and socio/economic group. However, it is too soon to say which, if any, of these possible areas of enquiry will be examined as future developments depend largely on the availability of resources.

The reactions of teachers and others to the research project have been very favourable and suggest that there is a need to encourage children of all ages to be aware of litter, as part of a process of developing responsible attitudes to the environment.

The research showed that the specially designed materials achieved their stated aim of increasing children's awareness of litter and acted as a satisfactory support and stimulus for a project based on the subject of litter and leading on to topics of wider environmental interest. It is possible to say that children in primary schools can produce worthwhile work, involving subjects in a variety of curriculum areas as a result of using the learning materials. Observers and teachers alike have been surprised by the children's depth of interest and by their ability to speak with informed confidence about what they were doing. They have also been impressed by the seriousness of children's thinking about environmental problems, by the noticeable change in their observed behaviour and by their increased awareness of litter and concern for their environment.

This research experience leads us to the conclusion that if children are given the opportunity to experience an environmental problem and to study it in a structured way and at a depth appropritate to their educational development, they will become more concerned about and more aware of, not only that particular prob-

lem, but of the environment generally. From the starting point of litter, children have gone on to study such varied topics as resource depletion, water pollution, re-cycling, packaging, vandalism and graffiti and have become involved in a variety of environment improvement projects. Other environmental problems, such as noise and air pollution could be studied in the same way. In some schools this is already happening, but only with the few teachers who are interested in and committed to the problem. It will not happen to any significant degree unless teachers are given explicit guide lines and the support of specially designed learning materials.

NATIONAL SOCIETY FOR CLEAN AIR

45th ANNUAL CONFERENCE
2-5 OCTOBER 1978
BRIGHTON

IS ENFORCEMENT OF EXISTING LEGISLATION ADEQUATE?

by

D.G.T. Williams,
Emmanuel College, Cambridge

136 North Street
Brighton BN1 1RG
England

'The development of air pollution control in Great Britain has been essentially pragmatic. As an early industrial country Britain has generally built up her law and administration stage by stage in response to particular problems. As a result the law relating to air pollution is to be found in a number of statutes, while the administrative arrangements are a blend of central direction and local discretion ....'(1)

The pragmatic approach in air pollution control has resulted in a confusing variety of legislative provisions. In 1976 the Central Unit on Environmental Pollution identified the following as the principal statutes governing air pollution: the Alkali etc. Works Regulation Act 1906; the Health and Safety at Work etc. Act 1974; the Public Health Acts 1936 and 1961, the Public Health (Recurring Nuisances) Act 1969 and the Public Health (Scotland) Act 1897; the Clean Air Acts 1956 and 1968; the Radioactive Substances Act 1960; the Control of Pollution Act 1974; and the Road Traffic Acts 1972 and 1974.(2) In addition one has to take account of -

(a) subordinate legislation made under powers granted by statute: e.g. the regulations relating to the use of the powers contained in Part IV of the Control of Pollution Act 1974 'by virtue of which local authorities can obtain information about industrial emissions to the atmosphere and, for the purposes of informing the public, can then publish that information.'(3)
(b) the consequences of membership of the European Economic Community. By 1976 it could already be stated that, as a result of EEC work on various aspects of air pollution, 'agreement has been reached on a directive concerning the sulphur content of gas oils, and proposals for a reduction of the lead content of petrol and for the sulphur content of fuel oil are under discussion.'(4)
(c) the consequences of the Scotland Act 1978 and the Wales Act 1978, if the devolutionary proposals are approved by referendum in Scotland and Wales respectively: separate arrangements are made for Northern Ireland under the present law.

Yet a further complicating factor is that the terms of reference of any study of air pollution seem to vary considerably. The Royal Commission on Environmental Pollution, in its First Report in 1971, (5) devoted a whole chapter to the 'global effects' of atmospheric pollution (with reference to 'alarming suggestions that substantial, irreversible and even catastrophic changes in world climate may occur within a few decades if man's activities continue unchecked'(6)); the Organisation for Economic Co-operation and Development (OECD) has been concerned with studying the long-range transport of air pollutants;(7) and the Clean Air Council - which was set up under the Clean Air Act 1956 to keep under review 'the

progress made (whether under this Act or otherwise) in abating the pollution of the air in England and Wales' - has recently taken an interest in tobacco smoking in public places.(8)

The scope of any inquiry relating to air pollution is inevitably influenced by such factors as the purpose for which the inquiry is undertaken (for instance, pollution in the context of energy resources (9)), public anxiety about the sources and effects of particular types of pollution, the extent to which problems can be identified for scientific or other investigation, and the different mechanisms of control. For most people the subject of 'air pollution' or 'clean air' would encompass familiar problems of domestic and industrial air pollution. Radioactivity and nuclear power would be excluded on grounds of range and complexity - hence the need for separate and detailed study in the Sixth Report of the Royal Commission (10). The line is not always so easily drawn. In reviewing recent changes in the environment, the Royal Commission in its Fourth Report briefly considered air pollution from motor vehicles and recognised the pressure for higher standards for vehicle exhaust emissions (11); but air pollution arising from motor vehicles was excluded from the terms of reference for its Fifth Report (Air Pollution Control: An Integrated Approach) because 'the mechanisms for controlling its emission' were regarded as 'quite different' from those relating to domestic and industrial air pollution (12).

Motor vehicle exhausts had in fact been covered in a section of the Beaver Committee Report on Air Pollution in 1954, with particular reference to diesel engine emissions (13). The Committee found that the relevant law was explicit and adequate but that the enforcement of the law left much to be desired (14). There is still concern about the effectiveness in practice of the legal restrictions on vehicle emissions: this is one of the areas of pollution where the police are directly involved in enforcement both in roadside checks and in prosecutions. In efforts to improve the law, with emphasis upon the composition of the fuel used as well as upon the construction and maintenance of vehicles, the nature and extent of police involvement perhaps need reconsideration (15). Complaints are frequently made about the danger or nuisance caused by vehicle emissions. However the law might well be directed towards better and stricter methods of prevention rather than towards more prosecutions and heavier penalties, and the role of the police might be steadily reduced in consequence.

Preventive action looms large in all aspects of pollution control, and a fair assessment of the effectiveness of air pollution

legislation has to be undertaken against a background of the numerous factors which should be weighed in the balance at different stages of control. The Royal Commission formulated this definition of the aim of air pollution control:

'The aim of air pollution control should be to reduce and when necessary eliminate hazards to human health and safety, taking into account both the magnitude and the certainty of the risks, including the susceptibilities of critical groups, and the resulting costs to the community; to reduce damage to amenity, property and plant and animal life to a minimum compatible with the wider public interest (which will take into account such factors as economics, employment and trade); and to prevent irreversible damage to the natural environment.'(16)

With that definition in mind, it is convenient to examine air pollution legislation of the kind considered by the Royal Commission - namely, domestic and industrial air pollution. Apart from various books published on pollution, (17) the principal sources for any discussion of Clean Air are the Report of the (Beaver) Committee on Air Pollution in 1954 (18) and the Fifth Report of the Royal Commission on Environmental Pollution in 1976 (19). From time to time the adequacy of existing legislation is questioned, usually with reference to some particular event or some particular problem, and it is doubtless impossible - in an area subject to so much scientific uncertainty and to fluctuating social, economic and moral pressures - to provide control arrangements which will satisfy all interests and meet all needs. The adequacy of enforcement of existing legislation is also questioned, and there are occasional demands for more investigation and more prosecutions in order to deter those who flout the law. The effectiveness of legislation, however, should not be confused with its enforcement: and it would be wrong to regard proceedings in the courts of law as other than a residual method of controlling air pollution. In looking broadly at both effectiveness and enforcement, it is desirable to consider the legislative and administrative framework of air pollution control, the role of the general public, and the methods available for ensuring the observance of rules and standards.

THE LEGISLATIVE AND ADMINISTRATIVE FRAMEWORK

Arrangements for the control of air pollution in this country have rested, in the words of the Royal Commission, upon the 'Dichotomy between central control for the more difficult industrial air pollution problems and local control for emissions from other industrial and from domestic sources.'(20) This division of

responsibility evolved in the nineteenth century and has been endorsed by the Beaver Committee and the Royal Commission. But there has been recent reorganisation both at central and local government level, leaving an understandable uncertainty about future relationships.

At central government level, as the Royal Commission put it, 'most pollution problems are the responsibility of the Department of the Environment (DOE) in conjunction, as appropriate, with the Scottish and Welsh Offices. The DOE is concerned with air pollution, fresh-water pollution, refuse disposal, radioactive wastes, oil on beaches and noise other than aircraft noise. The Secretary of State for the Environment also has a general co-ordinating role on pollution matters as a whole, which is exercised through a Central Unit on Environmental Pollution within his department.'(21) Despite the overall responsibility for matters relating to air pollution, however, the principal central agency on air pollution - H.M. Alkali and Clean Air Inspectorate - was transferred on 1st January 1975 from DOE to the Health and Safety Executive (which had been set up under the Health and Safety at Work etc. Act 1974) under a different Department (22). The Royal Commission in its Fifth Report recommended that the Alkali Inspectorate should be restored forthwith to direct DOE control pending the setting up of a new central inspectorate on pollution. There has been no progress in either direction - for restoring the Alkali Inspectorate to DOE or for setting up the central inspectorate - and, to judge from comments in the recently-published 1976 Report of the Alkali and Clean Air Inspectorate, there is strong opposition to any re-transfer of functions: the Health and Safety Commission consider that 'it would be undesirable administratively and on grounds of cost for an Inspectorate in the Department of the Environment to consider industrial processes from an environmental point of view while the Health and Safety Executive was required to consider the same processes in relation to the health and safety of Man.'(22)

The Alkali Inspectorate's remit is to control pollution to the outside air from scheduled processes. At the end of 1975 there were 3,130 such processes registered at 2,134 works; and a major revision of the list of scheduled processes was put in hand towards the end of 1976. The Inspectorate has come a long way since it was first formed in 1863 to control the emission to air of hydrochloric acid gas from the first stages of the Leblanc process for making alkali, or sodium carbonate. It nowadays has wide powers over the works under its jurisdiction. The registered works are under a duty to use the best practicable means for preventing the emission into the atmosphere from the premises of

noxious or offensive substances and for rendering harmless and inoffensive such substances as may be so emitted. In practice, though the term 'best practicable means' was first incorporated in a statute as early as 1874, industry must - as the Royal Commission put it - observe 'best practicable means to the satisfaction of the Alkali Inspectorate' (24): this implies considerable flexibility in approach and considerable discretion entrusted to the Inspectorate. With authority to prescribe in detail the best practicable means for each type of process and to some extent for each individual works, the Alkali Inspectorate is performing a legislative as well as an administrative function. Parliament has implicitly delegated its powers of control. This means, for instance, that the standards to be invoked in any prosecution for contravention of the law are derived, not from Parliamentary or subordinate legislation, but from the discretionary rulings of the Alkali Inspectorate. There may be every ground for supporting the Royal Commission's view that best practicable means should remain the basis of control, but it should also be recognised that it is an unusual basis for the operation of the criminal law.

At local level, since the reorganisation of local government in England and Wales from 1st April 1974, air pollution control has been the responsibility of the new district councils and of the London borough councils. These bodies - and their equivalents in Scotland - exercise a wide measure of control over air pollution from all non-registrable processes and from domestic premises. Most of them employ qualified Environmental Health Officers. The local authorities exercise various types of air pollution control:

(a) Domestic smoke control. Smoke from domestic chimneys is controlled under the Clean Air Acts 1956 and 1968, under which local authorities are empowered to create smoke control areas where it is an offence to emit smoke from any chimney unless the premises concerned have been expressly exempted. Works which come under the jurisdiction of the Alkali Inspectorate are not subject to smoke control orders, and we are told that 'other industrial plants which cannot avoid emitting smoke are normally exempted, with or without conditions, from orders.' (25) Domestic emissions still constitute 'a major air pollution problem' (26): the gradual imposition of smoke control orders has been one of the success stories of Clean Air legislation but, as the Royal Commission stressed in its Fifth Report, there is still much to be done to reduce the smoke and (to a lesser extent) the sulphur dioxide coming from houses. The statutory procedures associated with domestic smoke control bring into play numerous discretionary powers, including the decision whether or not to seek an order (though the Minister has power to direct a local authority to act

for a particular area). Those people affected by a proposed smoke control order are entitled to object to the Minister and to have the objection heard, though in practice 'few objections are made and fewer upheld, so that orders are normally confirmed with no significant modifications.'(27) After confirmation of an order the local authorities have discretionary powers in relation to grants towards the conversion of fireplaces - and, as Oldham Metropolitan Borough Council discovered in 1977, those powers are not immune from investigation for maladministration by a Local Commissioner. Local authorities also have discretionary power to prosecute for criminal offences relating to smoke control orders.

(b) The Clean Air Acts 1956 and 1968: industrial provisions. In its Fifth Report the Royal Commission identified three major controls which the Clean Air Acts provide over industry, concerning smoke from industrial premises, chimney heights, and grit and dust. Local authorities may also ask the Secretary of State to allow specific registered works to come under their control (through the Clean Air and Public Health Acts), but relatively few applications have been made. There is no formal relationship between local authorities and the Alkali Inspectorate, but arrangements for the control of air pollution obviously benefit from close co-operation. The Royal Commission made recommendations designed to ensure a closer relationship in the future, especially when one bears in mind that complaints about emissions from registered works (which, in strict law, are solely under the supervision of the Inspectorate) are frequently made to local authorities in the first instance.

(c) The Public Health Acts. Prior to the enactment of the Clean Air Acts, local authorities had to rely almost exclusively upon the Public Health Acts for their authority in controlling air pollution. The surviving relevant provisions of the Acts remain important, however, and cumulatively give local authorities their principal weapon in respect of non-combustion processes. Confining oneself to the Public Health Act 1936, the provisions to note are sections 91-100 (on 'statutory nuisances') and sections 107-108 relating to offensive trades.

The concept of statutory nuisance, which extends beyond matters of air pollution, includes 'any dust or effluvia caused by any trade, business, manufacture or process and being prejudicial to the health of, or a nuisance to, the inhabitants of the neighbourhood' (s. 92(1)(d)). The legal position is summarised as follows in Pollution Paper No. 9:

'If a local authority is satisfied that a nuisance exists it must serve on the person responsible a notice requiring him to take whatever steps (including closure or carrying out remedial measures) are necessary to abate the nuisance. If he fails to comply with the notice the local authority may apply to the Magistrates' Court for a nuisance order commanding compliance, and on conviction the court may also impose a fine not exceeding £200. A nuisance order may still be made under the Public Health (Recurring Nuisances) Act 1969 even though the nuisance has abated, if the court is satisfied that it is likely to recur. The local authority may itself do any work necessary to implement the order and recover the cost from the person responsible. Any person aggrieved by a nuisance may apply direct to the Magistrates' Court for an order without waiting for the local authority to act .... It is a defence to certain nuisance order proceedings in the Magistrates' Court, including those in respect of dust and effluvia, that the best practicable means were being used to prevent nuisance. The local authority (in England and Wales) may, however, elect to proceed in the High Court in which event the use of best practicable means is not a conclusive defence. In England an application may not be made by a local authority in the Magistrates' Court for a nuisance order against a works controlled by the Alkali Inspectorate without the consent of the Secretary of State for the Environment (or in Wales, the Secretary of State for Wales)'. (28)

Under these powers on statutory nuisances, according to the Royal Commission, 'action to deal with air pollution cannot be taken until after a nuisance has been caused. In contrast one of the main strengths of the Alkali and Clean Air Acts is that they provide for approval by the controlling authority before a new plant can be operated, and require consideration to be given to pollution abatement from the outset.'(29) But local authorities have somewhat stronger preventive powers in relation to offensive trades - especially those which cause smells - under sections 107 and 108.

There is some confusion about the scope of the various provisions in the Public Health Act and about the extent to which they overlap with other statutory powers on air pollution. Particular difficulty has arisen over section 100 which provides: 'If in the case of any statutory nuisance the local authority are of the opinion that summary proceedings would afford an inadequate remedy, they may in their own name take proceedings in the High Court for the purpose of securing the abatement or prohibition of that nuisance, and such proceedings shall be maintainable notwithstanding that the authority have suffered no damage from the nuisance.'

Proceedings under section 100 are civil only, and no fine can be imposed: but an order imposed by the High Court would have to be complied with, the sanction being imprisonment for contempt of court, and for some works compliance can be assured only by closure. Local authorities can bring proceedings against registered and non-registered works alike, and in neither case is there any requirement of consent from the Secretary of State. If the action succeeds, local authorities are under no obligation to pay compensation - as they might be if, under planning law, they sought to revoke planning permission or to serve a discontinuance of use order on a works. There are two built-in restrictions: first, the proceedings must relate to a 'statutory nuisance' as defined in the Act, and, secondly, it must appear (surely the local authority's view is not beyond challenge in this regard) that summary proceedings would afford an inadequate remedy. Even so, local authorities can now circumvent those restrictions by virtue of section 222 of the Local Government Act 1972 which allows them to seek an injunction or other remedy 'for the promotion or protection of the interests of the inhabitants of their area' without any consent from the Attorney-General: such proceedings could be brought in relation to any nuisance, statutory or non-statutory, and again without any requirement of compensation if the action succeeds.(30)

The potential of section 100 has been shown in fairly recent cases where local authorities, faced with alleged smell nuisances, took proceedings which led to the closure of premises. This development caused some concern at central government level, and the Department of the Environment issued a circular in 1976 reminding local authorities that smell problems caused by the animal waste processing industry have to be balanced, in any assessment of the desirability of legal proceedings, against the fact that 'without sufficient processing capacity a potentially serious waste disposal problem will arise.'(31) In other words, local considerations have to be balanced against national considerations. In its Fourth Report the Royal Commission, recognising that smells are a source of annoyance to many people, had this to say:

'The growing sensitivity of the public proboscis is demonstrated by the doubling of complaints in ten years. Many of them refer to the animal by-products industry, including such useful trades as gut-scraping and fellmongering. Good management is usually the best remedy, but research and development may be fruitful in some areas. The Chief Alkali Inspector, in his report for 1972, drew attention to a difficult situation: local authorities bring legal actions and may compel works to close, but "without these works the country could find itself in a real mess. A major factor in

minimising odour is the local availability of animal waste treatment works, so that offal and the like can be quickly treated before putrefaction becomes appreciable".'(32)

The Public Health Act in its present form serves as a reminder of the importance of the role of local authorities in the control of air pollution. Another example is the power to enter premises allowed by section 287 of the 1936 statute, which is couched in wide terms to enable entry for some specified purposes and 'generally, for the purpose of the performance by the council of their functions under this Act ....' Even registered works are subject to the power of entry, so it is argued - correctly, if one bears in mind the scope of section 100 alone. The wide discretion entrusted to authorised local officials is indicated in the following passage from the Fifth Report of the Royal Commission:

'Environmental Health Officers can greatly assist Alkali Inspectors by the prompt handling of complaints from the public about registered works; by informing the firm and the Inspector concerned as quickly as possible and, if the complaint seems sufficiently serious, by visiting the works themselves. We note that some Environmental Health Officers maintain that they have no power to enter these works. Others argue that sections 91, 92 and 287 of the Public Health Act 1936 allow them to enter and examine any process thought to be causing a nuisance or potential nuisance, registered or not. Our reading of the law is the same, but as there appears to be some doubt we suggest that it should be tested in the Courts or otherwise clarified.'(33)

The Royal Commission made it clear at a later stage of the Report that the powers of Environmental Health Officers should be settled in order to remove any doubts:

'Environmental Health Officers should have a clear statutory right to enter registered works where they have reasonable grounds to suppose that consent conditions for the works are not being observed. They would have no powers to require a works to take any action over specific emissions. We envisage that they would establish the facts about a particular emission and report their findings to the District Alkali Inspector as well as to the firm concerned, and, of course, to their own employers. In this way the local knowledge of Environmental Health Officers and the fact that they are generally in a position to observe industrial emissions on a day-to-day basis would be allied with the Alkali Inspectorate's expertise to bring about more effective supervision of emission performance.'(34)

It should perhaps be noted that the suggested requirement of 'reasonable grounds' for supposing that consent conditions are not being observed would be an improvement on the terms of section 287 as it stands. Some of the doubts about the present scope of the power of entry may reflect a reluctance on the part of some local officials to invoke a provision which virtually gives unrestricted discretionary power and could lead to officious and unnecessary entries onto premises. There is much to be said for injecting a requirement of 'reasonable grounds' into several powers of entry under section 287, but it seems especially desirable in respect of registered works which, after all, are not a direct responsibility of local authorities for the control of air pollution.

(d) Planning and Pollution. The Royal Commission expressed its concern, in the Fifth Report, 'that pollution is not always given top priority' in the planning process, adding that 'it is often dealt with inadequately, and sometimes forgotten altogether.'(35) Hence it made several recommendations, which need not be considered here, designed to achieve a better and more consistent recognition by planners of issues of pollution at all stages of the planning process (36). For major developments the Commission favoured the idea of environmental impact assessments - the possibilities of which are being widely studied at the present time. The Commission also explored some of the anomalies which arise when planning overlaps with separate statutory schemes in the control of air pollution: it sought to discourage, for instance, the use of planning conditions as a means of controlling air pollution from industrial plants, especially registered works, and it made some proposals for a more equitable system of compensation where a works has to be closed down. The underlying problem about planning and pollution, of course, is the familiar one of balancing national and local considerations: the interests of the central government are likely to be expressed, not always consistently, by a number of Departments and agencies, and at local level there are likely to be widely differing responses to the often conflicting considerations of health, amenity, jobs and housing. At the very least, local authorities need to have access to expert guidance and assistance; and the Royal Commission's central proposal for a new unified inspectorate at the centre (Her Majesty's Pollution Inspectorate) was as relevant to planning as to any other aspect of air pollution control. The existence of such bodies as the Clean Air Council (since 1956), the Royal Commission on Environmental Pollution (since 1970) and the Commission on Energy and the Environment (since 1978) is a further reflection on the need for standing arrangements to overcome difficulties inherent in the entrenched but troublesome partnership between local and central government in controlling all forms of pollution

including emissions into the atmosphere. The enormous apparatus of planning is, for its part, an added reminder of the extensive discretionary power which local authorities are called upon to exercise in the control of air pollution.

THE ROLE OF THE GENERAL PUBLIC

To-day, as evidenced by the report of the Royal Commission and by innumerable news features and items of correspondence in the press, public interests in all aspects of environmental pollution is high. Not only the cleanliness of the air and of rivers, but also the cleanliness of the earth and of the sea have become matters of serious concern to the public: and to these may be added the problem of pollution by noise. The interest shown by people all over the world in the Stockholm Conference of 1972 is one marked indication of the increased attention being paid to the subject by ordinary people .... 'The general public, more literate and educated than formerly, feel that as intelligent, thinking people on the receiving end of industrial emissions, they have a right to full and reliable information about those emissions from authoritative sources. They are no longer content to be told by experts what is and is not tolerable, but wish to have access to the evidence and to have the opportunity to judge for themselves.' (37)

That statement comes from the Report of the Working Party which (under the chairmanship of Admiral Sharp) had considered the general problem of information about industrial emissions to the atmosphere. The Working Party's proposals resulted, in a modified form, in the provisions of Part IV of the Control of Pollution Act 1974, under which regulations have subsequently been issued (38). By virtue of Part IV local authorities can obtain information about industrial emissions to the atmosphere and, for the purpose of informing the public, can then publish that information. Section 80 empowers local authorities to issue notices to the occupiers of any premises in their areas asking for 'such estimates or other information as may be specified or described in the notice concerning the emission of pollutants and other substances into the air from the premises.'

The Royal Commission on Environmental Pollution had given an initial stiumuls to the movement for greater openness in its comments in the Second Report (39). In the Fifth Report the Royal Commission welcomed Part IV of the Control of Pollution Act as a step in the right direction: but it regretted the reluctance of the Alkali Inspectorate to collect and release information directly. Reference was made to 'the Inspectorate's long-standing

policy to regard such information as the property of the firms concerned, and to refuse its release to the public on the grounds that this would jeopardise their relations with industry.'(40) It was also noted that the Health and Safety at Work etc. Act 1974 'effectively prevents the Alkali Inspectorate from making public details of emissions from registered works except with the owner's consent; there is no such bar on local authorities releasing information on non-registered works.'(41)

The relevant statutory provisions about information on air pollution apart from those in Part IV of the Control of Pollution Act, appear to be section 28 of the Health and Safety at Work etc. Act 1974, section 26 (as amended) of the Clean Air Act 1956, and section 287(5) of the Public Health Act 1936. Generally at the level of central government there is section 2 of the Official Secrets Act 1911, the reform of which is currently under discussion but which - in its present state or in a new statutory form - would cover information give to the Government by private individuals or concerns, whether given by reason of compulsory powers or otherwise, and whether or not given on an express or implied basis of confidence. The Official Secrets Act does not, of course, inhibit authorised disclosures. Strict adherence to a policy of confidentiality stems more from individual statutory provisions, such as that in the Health and Safety at Work etc. Act, and from entrenched official attitudes favouring confidentiality. The Chief Alkali Inspector, in the 108th Annual Report (for 1971) accepted the need for the public to be better informed, but he added a number of caveats: only a relatively few people are capable of properly assessing emission data and the Inspectorate should not be diverted from its real tasks 'to the non-productive task of educating numerous enquirers in the meaning of emission data, the reasons for variations and the potential effect on surroundings'; 'there are extremists in the environmental movement who believe in the use of scare tactics based on unbalanced information in order to sway public opinion'; and it would be wrong to endanger the evolving practice of co-operation with industry and co-operation by industry (42).

The Royal Commission had itself recognised, in its Second Report, that 'in the abatement of pollution there is already a close and constructive co-operation between industry and both central and local government, and that this co-operation has led to impressive improvements in the environment of Britain over the last two decades.'(43) Likewise there is wide acceptance of the need for specific safeguards in the context of provisions for greater openness. In Part IV of the Control of Pollution Act, for instance, an appeal to the Secretary of State is allowed against demands for

information the release of which could prejudice the interests of the State or a trade secret or which would be excessively expensive to prepare. The Sharp Report on Information about Industrial Emissions had paused to study 'the question whether an industrialist, by supplying, for publication, information about emissions to the atmosphere, might be acting in a way that could turn out to be prejudicial to his own interests by incurring risks of legal action.'(44) Such questions are bound to arise, and they demonstrate the complexity and difficulty of securing more information in a highly technical area.

In its Fifth Report the Royal Commission explored several ways of involving the public more directly in the processes of air pollution control, ensuring thereby greater accountability on the part of the controlling authorities and, in particular, the Alkali Inspectorate. Greater awareness on the past of the public, and greater involvement where appropriate, would do much to provide a more acceptable basis for enforcement of the law. The exercise of discretionary power in the control of air pollution should, in the Commission's view, be subject to formal scrutiny of a more extensive nature: the best practicable means for an industry, for instance, should in future be determined through a machinery 'which enables the views of amenity groups, the scientific community, local authorities and the general public to be taken into account as well as those of the industry.'(45) But, almost as a preliminary to any other changes, there should be a consolidation of the confusing statutory provisions relating to air pollution and an attempt to secure a more rational system of central and local control:

'We can see no good reason for these different legislative provisions for the control of emissions of different kinds. Moreover, these legislative differences appear to us to be inimical to the flexibility in control arrangements that we should like to see. The system has developed piecemeal as the need for action to deal with different aspects of air pollution was appreciated. The time has now come for new, comprehensive legislation to be enacted, appropriate to a flexible division of control between central and local government, and providing for the same basis of control whether industrial air pollutants originate from combustion or non-combustion processes.'(46)

Public participation in the control of air pollution has, of course, taken various forms. In the general area of planning there are ample opportunities in theory for the expression of views, although, as we have seen, it is difficult to combine pollution control with planning control. Complaints about

emissions into the atmosphere are regularly made by members of the public, usually to a local authority in the first instance, and the Royal Commission made some recommendations for improving the 'ombudsman' role of local and central controlling authorities. In some circumstances it is open to members of the public to bring civil proceedings with a view to abating a private nuisance caused by air pollution: the problems of adapting the law of tort to encompass atmospheric pollution have recently been explored by two legal writers, and it is their view that - despite the fact that the nuisance action 'can play at best a subsidiary role in any system of pollution control' - such proceedings 'may continue to prosper as a means of providing compensation for pollution victims.'(47) Private individuals are also entitled to bring prosecutions for criminal offences under some of the relevant legislation on air pollution. Proceedings for an offence relating to registered works under the Health and Safety at Work etc. Act 1974 are now, by virtue of section 38, restricted to those brought by an inspector ot to those which are brought by or with the consent of the Director of Public Prosecutions. In practice criminal prosecutions in other areas - under the Clean Air Acts and under the relevant provisions of the Public Health Acts - are undertaken 'by the relevant enforcement authority which alone may possess access to the necessary information and to the required powers of entry.'(48) In effect, then, the direct enforcement of legislation on air pollution with the ultimate sanction of criminal proceedings is chiefly a professional concern of the Alkali Inspectorate and of local authorities.

ENSURING THE OBSERVANCE OF RULES AND STANDARDS

It has never been the rule in this country 'that suspected criminal offences must automatically be the subject of prosecution', and we have frequently been reminded that the 'day-to-day business of prosecuting offences up and down the country is .... shot through with discretion.'(49) The discretionary element in prosecution is especially evident in those areas where proceedings are brought, not by the police or ordinary members of the public but by government departments or agencies or by local authorities. A valuable discussion of sanctions and enforcement in such an 'administrative' area of control is provided in chapter 9 of the Report of the Robens Committee on Safety and Health at Work.(50) The Committee had looked at the enforcement of several statutes including the Alkali etc. Works Regulation Act 1906 (and, of course, the Factories Act 1961), and it noted 'a very considerable body of opinion to the effect that the sanctions of the criminal law have only a very limited role to play in improving standards

of safety and health at work.'(51) Why should this be so? The Robens Committee explained their views:

'The fact is - and we believe this to be widely recognised - that the traditional concepts of the criminal law are not readily applicable to the majority of infringements which arise under this type of legislation. Relatively few offences are clear-cut, few arise from reckless indifference to the possibility of causing injury, few can be laid without qualification at the door of a particular individual. The typical infringement or combination of infringements arises rather through carelessness, oversight, lack of knowledge or means, inadequate supervision or sheer inefficiency. In such circumstances the process of prosecution and punishment in the criminal courts is largely an irrelevancy. The real need is for a constructive means of ensuring that practical improvements are made and preventive measures adopted. Whatever the value of the threat of prosecution, the actual process of prosecution makes little direct contribution towards this end. On the contrary, the laborious work of preparing prosecutions - and in the case of the Factory Inspectorate, of actually conducting them - consumes much valuable time which the inspectors are naturally reluctant to devote to such little purpose. On the other side of the coin - and this is equally important - in those relatively rare cases where deterrent punishment is clearly called for, the penalties available fall far short of what might be expected to make any real impact, particularly on the larger firms.'(52)

That statement, which was made with particular reference to occupational safety and health law, should not necessarily be accepted at face value. For instance, there is no reason why the sanctions of the criminal law should not apply to acts of carelessness and inadequate supervision, especially when one bears in mind that there are very many offences in English law for which a defendant may be convicted even in the absence of negligence.(53) But the Robens Committee was convinced that the courts - which 'are inevitably concerned more with events that have happened than with curing the underlying weakness that caused them'(54) - suffer from inherent weaknesses in dealing with technical problems of safety organisation and accident prevention. In future, it was recommended, the policy should be to institute criminal proceedings only for infringements 'of a type where the imposition of exemplary punishment would be generally expected and supported by the public. We mean by this offences of a flagrant, wilful or reckless nature which either have or could have resulted in serious injury. A corollary of this is that the maximum permissible fines should be considerably increased.'(55)

The increase in penalties has in fact recently been achieved for air pollution offences generally through the Control of Pollution Act 1974, Schedule 2 (with respect to the Public Health Acts and the Clean Air Acts) and through the Health and Safety at Work etc. Act 1974, section 33 (with respect to emissions from registered works). To combine increased penalties with selective prosecutions, however, carries a danger which the Robens Committee perhaps ignored: namely, that a policy of prosecuting only 'where the imposition of exemplary punishment would be generally expected and supported by the public' injects into each individual case a suggestion of pre-judgement which could both embarrass the defendant and influence a court. The role of the criminal courts ought not to be reduced to that of wielding the big stick at the behest of the prosecutor. From every point of view it would be preferable, so long as Parliament has provided for a wide range of seriousness in the types of offences which may be committed, to undertake prosecutions where and when they are deemed to be appropriate. Flagrant defiance of the law need not carry any serious risk of injury, but it might call for a prosecution (especially if the facts are relatively straightforward) which might in itself deter future conduct of a much more serious nature. On the other hand, a serious and apparently deliberate infringement of the law may not be regarded as worth the time, expense and unpredictability of legal proceedings where the accused is likely to produce a vigorous defence. The considerations relevant to a decision to prosecute are many and varied, and scope of discretion should not be as confined as that suggested by the Robens Committee.

The general approach towards prosecutions in the Robens Report, however, reflects the approach which the Alkali Inspectorate has adopted over the years. For many years after the passing of the 1906 statute there were scarcely any cases brought to court,(56) and even in the past decade the number of prosecutions has been tiny. Where emissions are regarded as having exceeded the proper limits, the normal practice of the Inspectorate is to issue infraction letters and only to prosecute as a last resort. The listed infractions for the six years from 1970 to 1975 were 25, 38, 58, 59, 57 and 70; the number of prosecutions in each year was 2, 3, 3, 5, 2 and 2 respectively - though a conviction was secured in all but two of the cases. Occasionally, as the Chief Alkali Inspector has noted in his Annual Reports, proceedings have had to be dropped; and it is evident that the process of collecting evidence and preparing prosecutions raises a number of difficulties. Nevertheless the Inspectorate has consistently favoured a policy of co-operation rather than confrontation with industry. The Royal Commission, in its Fifth Report, had this to say:

'The present system of control has achieved great advances in the reduction of emissions and we are satisfied that much of this progress may be attributed to the policy of persuasion and co-operation with industry that the Inspectorate have adopted. An aggressive policy of confrontation, involving prosecution for every lapse, would destroy this basis of co-operation; it would harden attitudes and dispose industry to resist the imposition of costly programmes for pollution abatement. We accept that such a policy would be counter-productive. It would also be inappropriate. Industry generally is aware of its responsibilities in pollution control. If a firm has installed equipment to the satisfaction of the Alkali Inspectorate and is striving by all reasonable means to maintain its emission at an acceptable level, there is little to be gained by prosecution in the event of a pollution incident arising from, say, an unforseeable breakdown of equipment. On the other hand, the acceptance by industry of abatement measures does not necessarily mean that agreed practices for minimising emissions will always be observed at the works. For example, excessive emissions might arise from a process involving manual operations because of inadequate management supervision. There is a danger that infrequent inspections by the controlling authority, together with a known reluctance to prosecute, will encourage some works to be careless in their attitudes to the day-by-day control of emissions.'(57)

Prosecution, of course, follows upon investigation; and the process of investigation is difficult enough in the area of air pollution. The Royal Commission recognised some of the difficulties, arising from technical reasons and from problems of manpower, and recommended closer co-operation between central and local bodies in securing an improved system of monitoring and inspection.(58) Other proposals, including those relating to the issue of conditional consents by the Alkali Inspectorate, might also do much to ease the problems faced in exercising control. There is no doubt that prosecutions become more acceptable when they are preceded by an open and fair procedure designed both to reassure industry and to reassure the public. The desirability of keeping the public informed underlies the Royal Commission's suggestion that every infraction letter issued to a firm should be made public, 'so that after a period of time the effectivenss of this policy may be gauged.'(59) Prosecutions should follow as a matter of course, however, where infractions by a firm are frequent, and the Royal Commission felt that firm enforcement of the law in appropriate cases need not endanger the Alkali Inspectorate's co-operative relationship with industry.(60)

Since both the Robens Committee and the Royal Commission were satisfied that the courts should continue to have a role, albeit a residual role, to play in the control of air pollution, it may be that there should be further examination of the nature of legal proceedings in this technical area. The courts offer the often underrated advantages of independence and publicity, but there must be serious doubts about the competence of some courts to assimilate and adjudicate upon the types of issues presented to them. Perhaps the possibility of setting up specialist criminal courts, with judges and assessors, should be considered for air pollution and many other areas raising difficult technical matters. Short of such a development, there may be several ways in which the ordinary process of trial could be modified to take account of the special problems of pollution. The relatively low penalties which the courts at present impose may simply reflect the under-confidence of courts which are called upon to intervene once in a while in unfamiliar territory.

The same problem of infrequent prosecutions and low penalties can be seen in the different field of local authority prosecutions for contraventions of the Clean Air Acts by non-registered works. Figures presented to the Royal Commission suggested that 'local authorities prosecute in an even smaller proportion of cases than do the Alkali Inspectorate, despite their more modern legislation.'(61) In future, it was hoped, the Alkali Inspectorate will co-operate in enforcement against non-registered works as much as local authorities against registered ones. Local Authorities, of course, are also involved in the enforcement of the domestic smoke control provisions of the Clean Air Acts, including the offence relating to the acquisition or retail sale of unauthorised solid fuels in a building in a smoke control area. Here again there have been suggestions of a reluctance to prosecute and of low penalties imposed in the courts. Then there are the 'statutory nuisance' provisions of the Public Health Act 1936. In none of these areas of local authority involvement are there comprehensive figures available, and to make an assessment of the effectiveness of all the enforcement procedures would entail lengthy and detailed research. What is clear is that a policy of persuasion is broadly favoured rather than a policy of automatic enforcement through prosecution or other recourse to the courts. The Beaver Committee in 1954 - in making its recommendations for enforcing the law for the prevention of smoke, grit and dust - suggested 'that if it should seem necessary to take legal proceedings, local authorities should make it their practice to warn the potential offender in advance and advise him of the prevention measures they consider necessary. Legal action should follow promptly, however, if satisfactory steps are not taken.'(62)

The distribution of responsibility for air pollution control through central and local government makes it almost impossible to make a general assessment of the effectiveness of legislation relating to air pollution. What we have seen is an indication of the complexity of any system of enforcement for a highly technical field. Pollution often gives rise to considerable public anxiety, and it is right that any improvements in the present law on emissions into the atmosphere should be designed in part to increase the information made available and, where appropriate, the degree of public participation. But a precursor of changes in the law should be an attempt to consolidate the statutory provisions on air pollution with a view to avoiding unnecessary overlaps and confusion. The public is entitled to know what the law is on all areas of air pollution so that the effectiveness of the law can be assessed against a single statutory framework. In the actual enforcement of the law the emphasis is likely, for many years to come, to be upon prevention rather than prosecution, upon co-operation rather than confrontation.

FOOTNOTES

1. Pollution Control in Great Britain: How it Works. Pollution Paper No. 9 (HMSO, 1976) para. 17.
2. _Id._, at para. 20.
3. Circular 2/77 (DOE) and Circular 6/77 (Welsh Office) explains the 3 sets of regulations made under Part IV.
4. Pollution Paper No. 9, at para. 42.
5. Cmnd. 4585 (February 1971), ch. V.
6. _Id._, para. 96.
7. Pollution Paper No. 9, at para. 43.
8. Section 23(1)(a). See generally, Report of the Committee on Air Pollution, Cmd. 9322 (November 1954), paras. 119-20.
9. See _Energy and the Environment_ (Report of Working Party set up jointly by the Committee for Environmental Conservation, the Royal Society of Arts, and the Institute of Fuel, 1974), ch. 7.
10. Nuclear Power and the Environment, Cmnd. 6618 (September 1976).
11. Pollution Control: Purposes and Problems. Cmnd. 5780 (December 1974), paras. 48-52.
12. Cmnd. 6371, para. 8.
13. Cmnd. 9322, paras. 64-67.
14. Para. 67.
15. See Pollution Paper No. 9, paras. 36-38.
16. Fifth Report, Cmnd. 6371, para. 41.
17. See _e.g._, D.A. Bigham, _The Law and Administration Relating to Protection of the Environment_ (London: Oyez Publications, 1973); J. McLoughlin, _The Law and Practice Relating to Pollution Control in the United Kingdom_ (Graham and Trotman Ltd. for the Commission of the European Communities, 1976); R.S. Scorer, _Pollution in the Air. Problems, Policies and Priorities_ (London and Boston: Routledge and Kegan Paul, 1973).
18. Cmd. 9322.
19. Cmnd. 6371.
20. Cmnd. 6371, para. 52.
21. Cmnd. 5780, para. 164.

22. See 112th Report of HM Alkali and Clean Air Inspectorate, Report for 1975 (foreword).

23. Report issued 4 July 1978, para. 12.

24. Cmnd. 6371, para. 82.

25. Id., para. 54.

26. Id., para 53.

27. Id., para. 55.

28. Pollution Paper No. 9, paras. 26-27.

29. Cmnd. 6371, para. 113.

30. See H.W.R. Wade, Administrative Law (Oxford: Clarendon Press, 4th edn., 1977), at 513.

31. Circular 43/76 (Department of Environment). See also, Report of the Working Party on the Suppression of Odours from Offensive and Selected Other Trades. Part 1 (Assessment of the Problem in Great Britain), Warren Spring Laboratory, 1974, Appendix D.

32. Cmnd. 5780, para. 47.

33. Cmnd. 6371, para. 139.

34. Id., para. 225.

35. Id., para. 335.

36. Id., ch. XI.

37. HMSO, 1973, pp. 9-10.

38. See note 3 above.

39. Cmnd. 4894, paras. 3-10.

40. Cmnd. 6371, para. 125.

41. Id., para. 235.

42. HMSO, pp. 11-14.

43. Cmnd. 4894, para. 9.

44. HMSO, 1973, paras. 58-62.

45. Cmnd. 6371, para. 17.

46. Id., para. 199.

47. A.I. Ogus and G.M. Richardson, 'Economics and the Environment: A Study of Private Nuisance' (1977) 36 Cambridge Law Journal 284, 324.

48. Id., note 22 at p. 324.

49. See respectively, Sir Hartley Shawcross, A.-G., HC Debates, Vol. 483, c. 681 (29 January 1951); Geoffrey Marshall, Police and Government (London: Methuen, 1965), at p. 116.

50. Cmnd. 5034 (July 1972).

51. Id., para. 255.

52. Id., para. 261.

53. See Smith and Hogan, Criminal Law (London: Butterworths), 4th edn. 1978, ch. 5 and 6.

54. Cmnd. 5034, para. 255.

55. Id., para. 263.

56. Jeremy Bugler, Polluting Britain (London: Penguin Books, 1972) at p. 12.

57. Cmnd. 6371, para. 227.

58. Id., paras. 219 ff.

59. Id., para. 229.

60. Id., para. 228.

61. Cmnd. 6371, para. 232.

62. Cmnd. 9322, para. 111.

NATIONAL SOCIETY FOR CLEAN AIR

45th ANNUAL CONFERENCE
2-5 OCTOBER 1978
BRIGHTON

LOW ENERGY STRATEGIES FOR THE UK

by

Gerald Leach,
International Institute for Environment
and Development

136 North Street
Brighton BN1 1RG
England

The talk will present the results of a two-year study on how the UK could have a large growth in material standards over the next 50 years and yet keep primary fuel consumption no higher than (or well below) today's levels. Most of the fuel savings come from applying vigorously known or imminent technologies for saving the need for energy or using fuels more efficiently, and not from less certain contributions such as solar, wave and wind supplies. The study is based on a highly disaggregated analysis of how each main energy-using sector (industry, housing, offices, transport, etc.) uses fuels now, and could use them more effectively in future if the main thrust of policy was switched from providing more to using less. The key results for each sector and the overall results will be presented with a discussion of their environmental implications.

NATIONAL SOCIETY FOR CLEAN AIR

45th ANNUAL CONFERENCE
2-5 OCTOBER 1978
BRIGHTON

ENERGY CONSERVATION IN INDUSTRY

by

Dr. N.J.D. Lucas,
Imperial College of Science and Technology

136 North Street
Brighton BN1 1RG
England

INTRODUCTION

The conservation of energy in industry is an extremely complex subject, depending, as it does, on the details of energy use in the wide variety of industrial processes and depending, as it also does, on the motivations and actions of plant manufacturers, industrialists, civil servants and politicians. The obvious way of beginning to classify the material is into two broad categories - technological possibilities and political action. This classification has the disadvantage that many of the most interesting aspects of the subject arise from the interaction of political and technical factors, but it is convenient and I intend to follow it in this paper. I propose to begin with a discussion of some of the technological possibilities, and I shall try to bring out some of the obstacles to the implementation of these possibilities. Then I want to look at some government policy intiatives and see how, if at all, these measures help.

TECHNOLOGICAL POSSIBILITIES

REVIEW OF ACTIVITY

Broadly, measures to conserve energy can be broken down into three groups classified by a characteristic lead time, they are

immediate	- changes in operational practice involving little or no investment, e.g. replacing window panes, turning down thermostats.
medium term	- modification to existing plant or plant on the drawing board involving additional investment e.g. heat recovery, insulation of buildings.
long term	- changes in process design probably only practical on the plant after next.

The activity within each of these groups can be further classified according to the operating agency. We can distinguish

- internal industrial work
- government financed schemes
- independent institutions: universities, research associations, research establishments.

There are few industries that have not made some immediate response, there can be few that have not considered investment in modifications to existing processes, there are very few indeed that have thought hard about long term changes - those that have

are to be found amongst the large companies with considerable technical resources, ICI is one example.

The principal government financed schemes are the Energy Thrift schemes and Energy Audit. Preliminary reports from both these schemes are now available[1, 2]. The schemes are quite different in approach, but they have the common factor that they both obtain present information in a highly aggregated manner. The Energy Thrift scheme seeks to identify the potential for rapid savings and relies heavily on the experience of the investigations; no measurements are made. The Energy Audit scheme is designed to obtain information on the energy content of important industrial products; the principal weakness of the scheme is that there is no clear relationship established between the amount of energy used in making a product and the potential for reducing the necessary energy.

A variety of work is being done by independent institutions, on the medium and long term possibilities, about which it is difficult to generalise.

In the rest of this section I intend to talk about our own work at Imperial College, mainly of course because it is the work with which I am best acquainted, but also partly because I think it relates to what I presume to be your interest and that is the long term potential for energy conservation in industry. So, if I now confine myself to our own work, it is not exclusively out of folie de grandeur, but in order to give you a feel for the problems and limitations of one particular investigation.

Our aim is not to establish in one fell swoop the potential for energy conservation throughout industry. Our principal aim is to contribute to a methodology for examining in detail where energy goes on a site, where it is converted and with what efficiency. This analysis requires measurements to be made on site, but in an industrial environment there are tight constraints on what interference is permitted. Some ingenuity is necessary to combine factory records with available recordings and a few additional measurements to obtain energy flows for the site. I do not want to dwell on this aspect, because it is not of compelling interest unless one is about to undertake a similar investigation, but it is an important part of the motive for our work.

Our second stage is to establish how the production, transmission, conversion and use of energy could be made more efficient. Here we meet another methodological problem. We can only study a few sites, but we cannot resist the desire to generalise; we therefore have

to disassemble the energy flows on the sites we study into components which are common to many sites. A useful set of categories is:

Thermal performance of industrial building

Heat recovery

Energy use as a design variable

Control

Distribution of power

Combined heat and power

These are not a complete set of possibilities, and I do not intend even to talk about all of those which I have listed.

THE THERMAL PERFORMANCE OF INDUSTRIAL BUILDINGS

Until very recently there were no standards of insulation for other than domestic buildings. Many, if not the majority, of industrial buildings are in large part constructed from steel or asbestos cladding; the only way of reducing the thermal performance of a building of this construction is by taking away the walls or roof. The remaining buildings have only nominal insulation. Because of the substantial release of energy as heat within many industrial buildings, the effects of insulation on the length of the heating season can be dramatic. This is illustrated by a study which we made of a machine tool shop. Figure 1 shows the heat at present supplied to the shop over the year both as internal gains from the operations (which we measured) and as fuel burnt specifically for space heating. The figure also shows our calculations of the space heating demand based on an internal temperature of 20° C and details of the structure of the building. Agreement is not perfect, but it is satisfactory. Figure 2 shows our calculations of the heat requirement with technically possible, but perhaps extreme, insulation and control of ventilation. The internal gains are also represented; it can be seen that for five months of the year they exceed the average heating requirement. If we further assume that 50% of the heat now supplied to heat treatment ovens is recovered and used for space heating, then we find that the recovered heat plus internal gains exceeds the average space heating requirement every month except January. This is not the whole story, because in practice specific demands for heating up the building from cold or dealing with especially cold days would require heat in excess of average requirements. The space heating would be dominated by transient demands.

Nevertheless the savings would be considerable. The results of a more modest proposal for increasing the thermal performance of the building are shown in Figure 3; there is, even in this case, a saving of 95% of the fuel now being used.

You may think that the benefits of heavy insulation in winter would be offset by intolerably hot conditions in summer. But the reverse is the case. The internal gains are dissipated by ventilation, not by transfer across the fabric. Insulation prevents solar gains and actually reduces the internal temperature. Figure 4 demonstrates this point. In this figure the heat input (or cooling load) required to maintain an internal temperature of 20° C is shown throughout typical days in January and July for uninsulated and insulated buildings. The total gains in July are less in the insulated than the uninsulated buildings.

Evidently the detail of these calculations can be disputed, but the basic contention that very large savings are possibly by a combination of insulation and heat recovery can hardly be in doubt.

The next question is whether the proposed modifications are economic On a green field site the answer will generally be yes. Returns on capital will depend on circumstances, but they will be made. Retrofitting of insulation is a different proposition. Capital costs are higher and the costs of disturbance can be significant. The return will characteristically be 20% or so which most industrialists would not find compelling.

ENERGY CONSUMPTION AS A DESIGN VARIABLE

The next aspect of energy use in industry which I wish to consider in detail, is one to which I have given the formidable title, energy consumption as a design variable. What I mean is that, extraordinary as it may seem, the cost of the energy which a piece of equipment will consume over its life is rarely given adequate weight in the design of that equipment. A case which illustrates this point well is the insulation of industrial ovens. I regret to dwell on such simple technology as insulation, I have more elaborate examples later, but because the considerations are so simple it is possible to get a clear view of the principles at work. We studied the use of an ageing oven in a plant making aluminium extrusions. From a knowledge of the way in which the oven was used, the temperature and timing, we were able to calculate the optimum thickness of insulation for that oven in that context. The calculations are presented in Figures 5 and 6. The cost of monolithic insulation of the type suitable for the

application can be expressed as a fixed charge (suppressed in the figure) plus a charge proportional to the thickness. The cost is shown diagrammatically. Also shown is the present worth of the energy used to heat the oven as a function of thickness. The total present worth of the cost of the operation is the sum of these two curves. The thickness corresponding to the minimum present worth, is the optimum thickness. The calculation is shown for discount rates of 10% and 30%. The annual energy saving is also shown. A discount rate of 30% corresponds to common industrial practice; with this discount rate the optimum thickness applies 10cm. This seems reasonably close, but it is instructive to study the effects of the difference. In going from 10cm to 12cm the heat rate decreases from 14.3 to 12.0 kW, i.e. there is a 16% saving of energy in moving to the optimum, but the saving in the present worth of the total costs only decreases by 1%. The first cost of the oven increases by £400 which could be 3-4% of the total capital costs. By designing an oven with optimum characteristics the manufacturer could save 16% of energy use, decrease total costs by 1% and put up his price by 3 or 4%. The 1% decrease in present worth is a negligible incentive to the purchaser, but the 3 or 4% increase in first cost is a substantial deterrent. This irrational, but understandable, behaviour persistently causes equipment to be designed away from the optimum and as this example shows, small movements from the optimum can mean large changes in energy consumption. Figure 5 also shows the effect of discount rate. With a figure of 10%, the optimum thickness becomes 17 cm and the heat rate drops to 8.6 kW, an energy saving of 40% on present practice. 10% is the cost of capital at which energy is supplied by nationalised industry and is a reasonable figure to use in assessments of energy utilisation.

We have detected the same tendency in all other plant at which we have looked. Another interesting example is refrigeration. The efficiency of a refrigerator can be improved by increasing the area of the heat exchanger surfaces in the evaporator and the condenser - at a cost. The optimum design is a compromise between capital cost of the heat exchanger and the energy saved. Figure 7 shows our estimate of how the present worth of capital and running costs of refrigeration plant varies with heat exchanger size. The figure relates to a real investigation on a batch chemical plant. The contours link points of equal present worth, so we are looking for the lowest point. The axes represent the log mean temperature difference across the heat exchanger which is inversely proportional to the size of the heat exchanger. The particular example in the figure is done at a discount rate of 30%. The asterisk marks the present operating conditions. The contours are again shallow. The difference in present worth in moving from present operational

conditions to the optimum is between 10 and 15%, but the energy consumption would be reduced by 26%.

An example in a quite different application is given in Figure 8. This figure shows the power and kVAr drawn by a large hydraulic press extruding aluminium. A section of the recording has been chosen which shows a moment when power to the press was switched off. The difference between the power consumption when the press is idle but alive and when it is disconnected is about 75kW. This power is drawn by the three large electric motors which drive the press; it represents a standing loss in the motor which is present whether the press is in use or not. But the capacity of the three motors is only necessary at a single moment represented by the large spike. It is possible to redesign the press to operate on two motors plus sufficient hydraulic storage to meet the spike. The standing loss can be reduced by one third. This and other small modifications would permit a 15% saving in the energy consumption of the press.

I do not want to labour the point any further except to summarise that our studies and our conversations with manufacturers suggest that little notice is taken, by the purchaser, of the energy consumption even of energy intensive plant. Consequently, plant is persistently designed away from the economic optimum and uses more energy than is necessary.

COMBINED HEAT AND POWER

When electricity, or power, is produced from a prime mover it is associated with the production of heat at a temperature which depends on the nature of the prime mover and the way in which it is operated. If this heat can be put to a useful purpose then there is a possible basis for economies of fuel and money. The topic is complex and has been and still is, the object of endless discussion[3]. It is worth noting that the Secretary of State for Energy set up a working party in February 1975 to consider the economic role of combined heat and power in the U.K. which has not yet produced either its final report or a word on industrial applications. It is not possible for me to do justice to all the ramifications of the debate in this short time. I can only be dogmatic and sketch the principal lines of arguments and my own views.

Combined heat and power (CHP) is generally thought of in association with district heating. The disadvantages of this application are that an expensive heat distribution system has specially to be installed, furthermore the demand for heat is low at night and in

the summer, so the utilisation of this heavy investment is correspondingly low. The heat using infrastructure in industry is generally a non optional investment and load factors can often be high; industrial applications of combined heat and power are therefore more likely to be economic than those associated with district heating.

A substantial amount of electricity used by industry is generated on site, often in association with useful heat. Critics of CHP maintain that suitable sites are now exhausted. This proposition is probably true if one is looking for sites which will absorb all the heat and all the electricity produced; the requirement locally to balance heat and power supply is very restrictive. But there are many sites with large steam demands which could install CHP schemes and export power to the national grid. The price obtained from the monopoly buyer, the CEGB, is then crucial to the appraisal of the scheme. Needless to say, the determination of this price is very controversial. I do not think it is done fairly and I think this is only to be expected when a strong monopoly buyer faces a weak seller; but for a full discussion of the arguments the reader must look elsewhere. It is interesting that the only scheme of this nature to have been approved is a scheme devised by the Midlands Electricity Board which will generate power and heat from diesel engines, sell the heat to industry and distribute the electricity within their own system. This imaginative scheme was possible because the electricity supply industry was able to value the electrical output realistically. A similar scheme could never have been installed privately because the operator would not have received proper credit for the electrical output. Nor can one rely on other Area Boards grasping at the same opportunities. My own view is that within the present institutional structure only another state enterprise with the specific task of seeking out these opportunities and with the power to negotiate on relatively equal terms with the electricity supply industry - only such a body could succeed in significantly extending the practice of CHP in industry.

FUTURE POTENTIAL OF INDUSTRIAL ENERGY CONSERVATION

I have included a discussion of future potential because I felt it was expected: I am by nature reluctant to make predictions about the future. Moreover our own work is a small sample and not significant. On the sites which we have studied, energy savings of between 20 and 40% seem to us to be technically possible and economically sound, although they may not be taken up[2]. The conclusions of the Interim Report of the Energy Thrift Scheme were that average savings of 14% were achievable with the measures that they considered. It is difficult to compare our detailed assess-

ments of a few sites with their brief survey of many sites but one large difference appears to be in the potential for improved thermal performance.

What is clear, is that there is a large but uncertain potential for energy conservation which it is worthwhile trying to develop.

INHIBITION

There seems to be evidence of considerable inhibition in industrialists towards investment in energy conservation. No systematic work has been done, to my knowledge, to examine whether the apparent tendency for industrialists to reject investments in energy conservation in favour of financially less attractice options elsewhere is a real phenomenon and if so whether, if the behaviour is rational, if all relevant aspects are considered. In the absence of systematic work one resorts to impressions. My impression is that industrialists are inhibited, principally by two factors. One is uncertainty, the other is a preference for their own line of business.

The financial performance of investments in energy conservation is sometimes difficult to gauge, partly because it often depends on the response of the personnel. For example, admittedly an extreme example, one site we studied had installed plastic doors to control draughts, but the workforce had cut truck sized holes in them to drive in and out. Even the insulation of buildings, which looks good on paper, is difficult to predict. A logical response to this source of inhibition is government financed demonstration projects.

The other putative source of inhibition was the preference of industrialists for producing goods rather than consuming energy. One possible response is to bribe the industrialists by grants and/or cheap loans. But experience has shown that the financial incentive has to be substantial. An early government scheme which offered loans at a percentage point below the current rates of interest was a disastrous failure.

RECENT GOVERNMENT POLICY

It is interesting to consider some recent government initiatives in the light of the conclusions of our discussion. In June this year the Secretary of State for Industry announced a scheme of cash grants available to industry and commerce for improving heating plant, the insulation of premises and the provision, replacement

or modernisation of combined heat and power systems. Grants up to 25% will be offered for these energy saving measures. The government has set aside £25 million for the scheme, which will run for two years. The total investment mobilised will be £100 million, if all the grants are taken up, which should produce savings of £50 million per year. In my judgement, this scheme is likely to provide sufficient financial incentive to firms to overcome their natural preference to invest in areas directly related to production; I suspect that the scheme will be successful, but whether the government is justified in spending money to persuade industry is another matter.

Another recent initiative is the new requirement contained in the amendment to the building regulations of 1976, announced in June 78, whereby from June 1978 most new, non domestic buildings, will be required to have adequate thermal insulation. This is the first time that proposals for non domestic buildings will have to satisfy standards of insulation. This, as you will anticipate from what I have already said, I consider to be a valuable step. It is another way of overcoming some aspects of inhibition, by regulation.

In September 1977 the Secretary of State for Energy announced a £1.5 million programme of demonstration projects to show industry the potential for energy-saving, initially in the field of waste heat recovery. This scheme, based on a more ambitious French model, is aimed at reducing the uncertainty and risk involved in some energy saving investment by subsidising the first installation on the condition that the beneficiary should make the results of his experience available to others.

This list does not exhaust the measures taken by government; the number and diversity of measures that have been amended makes it impossible to give an exhaustive list here. A review is given in the Appendix.

The measures announced by government will have some effect on all but one of the obstacles to efficient use of energy which we detected in the early discussion. Whether the measures will be adequate is perhaps controversial, but there is one very pervasive aspect which is quite untouched; this is the consideration to which earlier I gave the title, energy use as a design variable. None of the measures so far announced will make manufacturers design more efficiently or make consumers buy more expensive, more efficient plant. It is tempting to suggest that government should legislate for performance standards for plant. But this is not practical; the difficulty of defining standards for the great

variety of plant used is discouraging enough, but it would have no purpose, because whether equipment is properly designed depends on the environment in which it will be used and the way in which it will be used. There is only one way of dealing with the problem and that is by education and information. This is an area where one could reasonably expect initiative from the engineering institutes; there has been enough attention paid by these bodies to broad scale evaluation of energy problems and technologies, but they have not, in my view, given enough thought to the task of encouraging discussion and awareness of energy use in specific engineering processes and operations.

REFERENCES

1. National Physical Laboratory (1977). Energy Audit Scheme, first progress report. CHEM 72 (EU2).

2. Department of Industry (1977). A preliminary analysis of the potential for energy conservation in industry.

3. See for example, Local Energy Centres, ed. N.J.D. Lucas, Applied Science Publishers, 1978.

Figure 1 Space heating requirements plus process heat gains compared with the theoretical predictions.

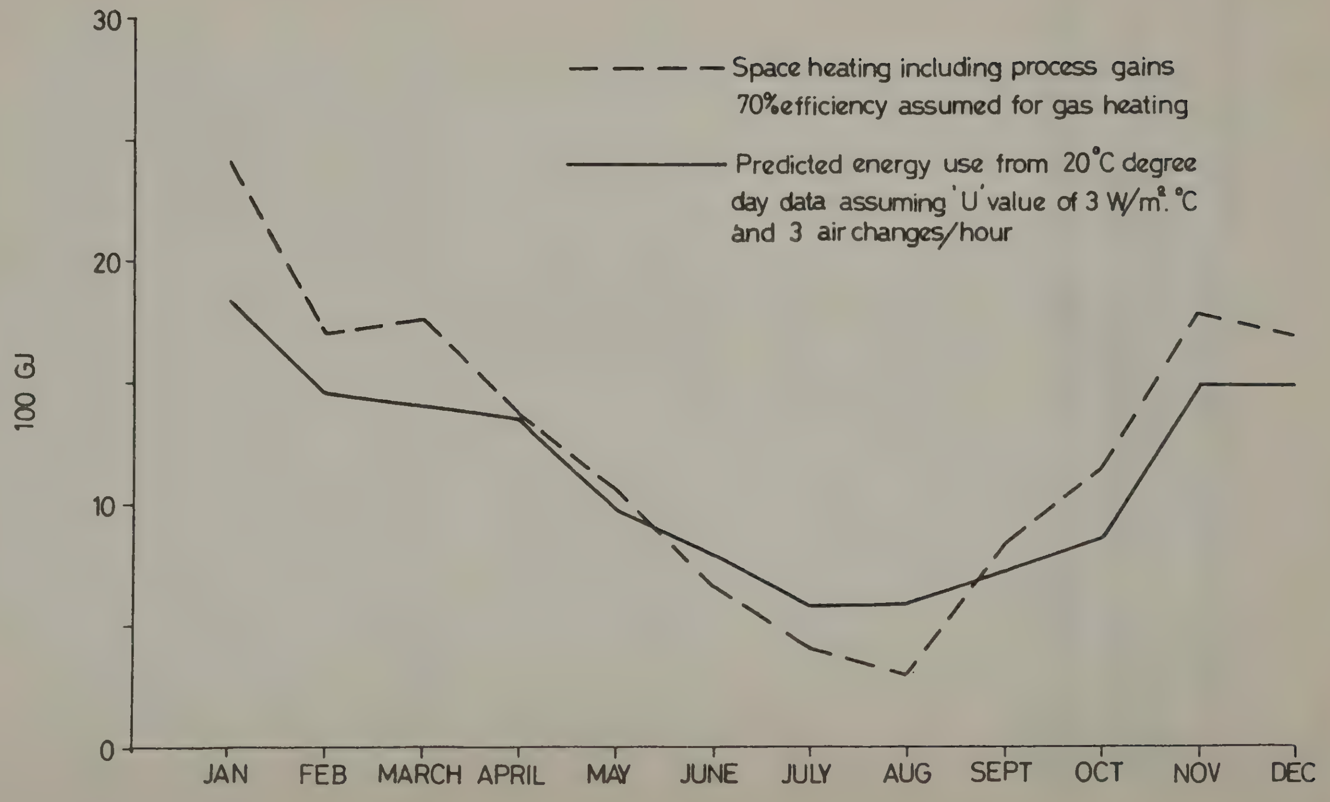


Figure 2 The required energy estimated for space heating with improved insulation and ventilation.

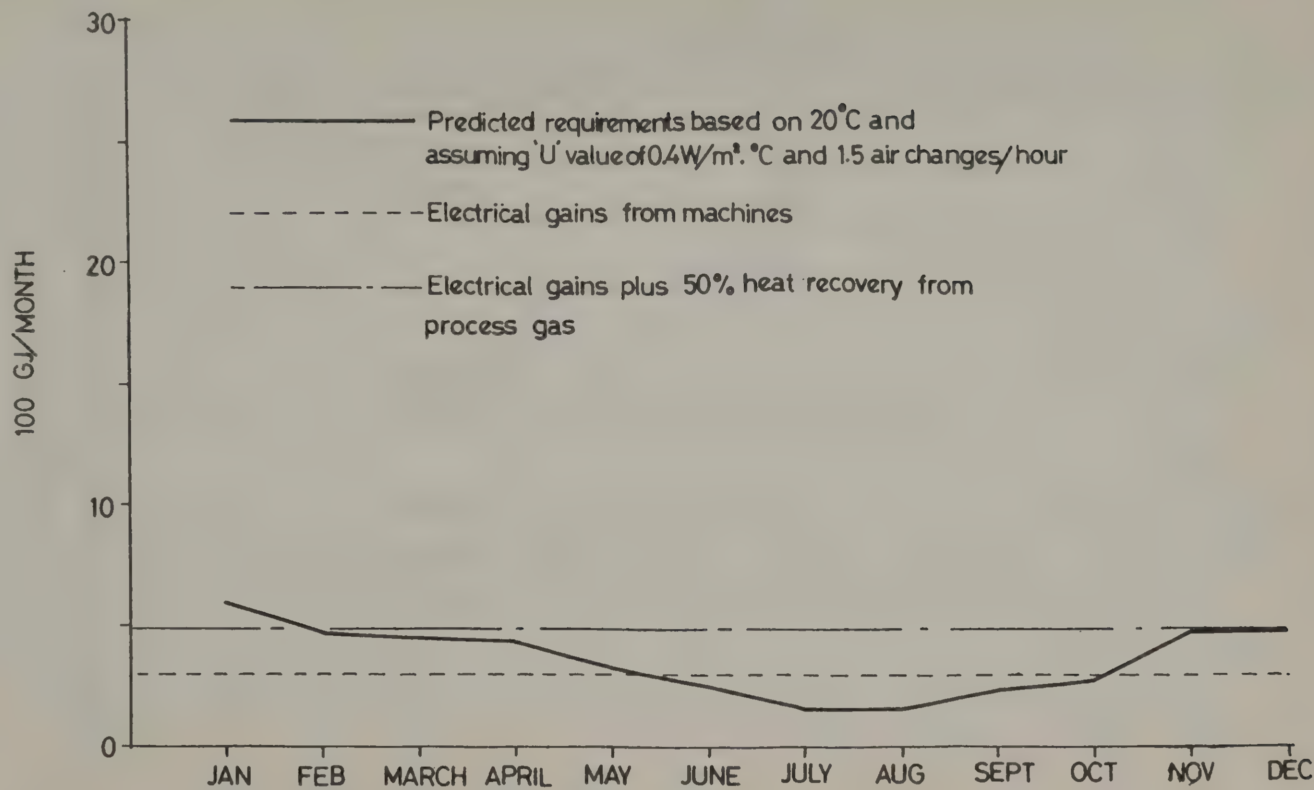


Figure 3 As Figure 2 with rigorous improvements.

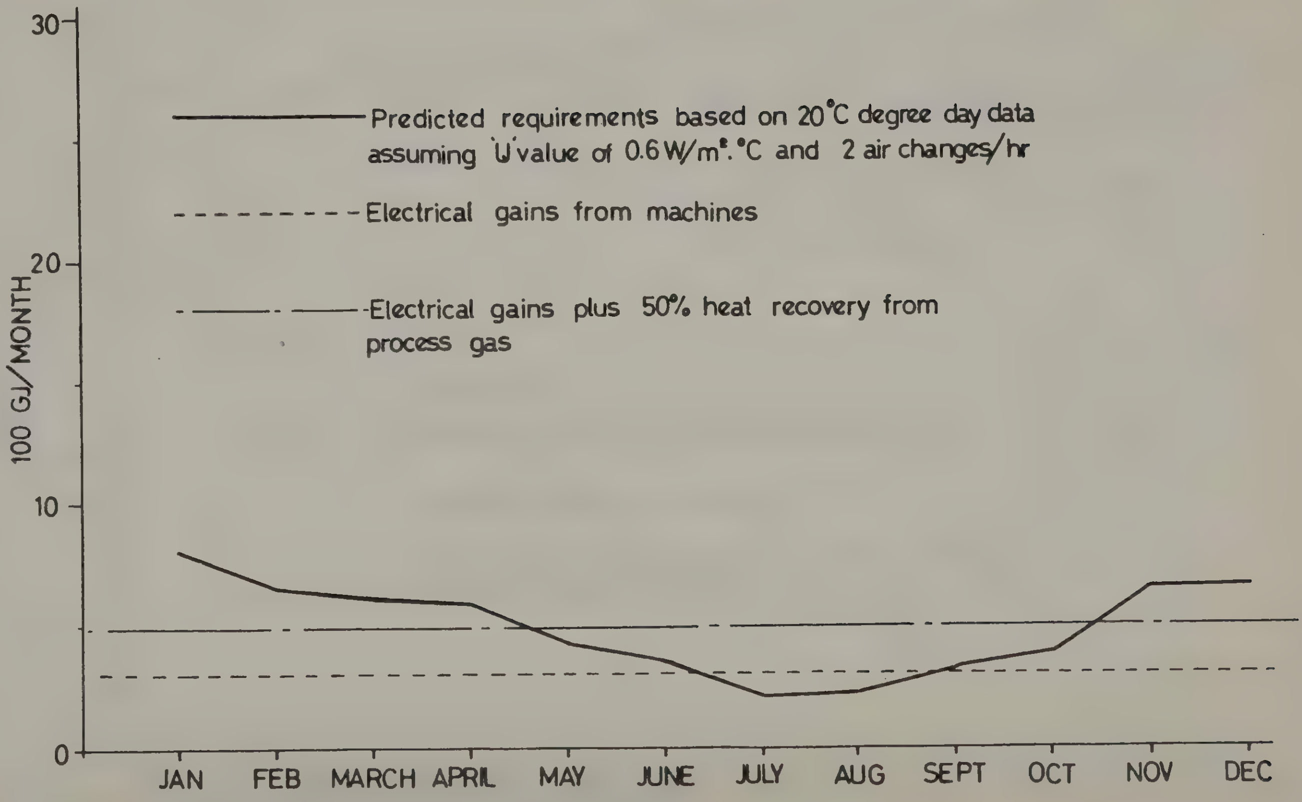
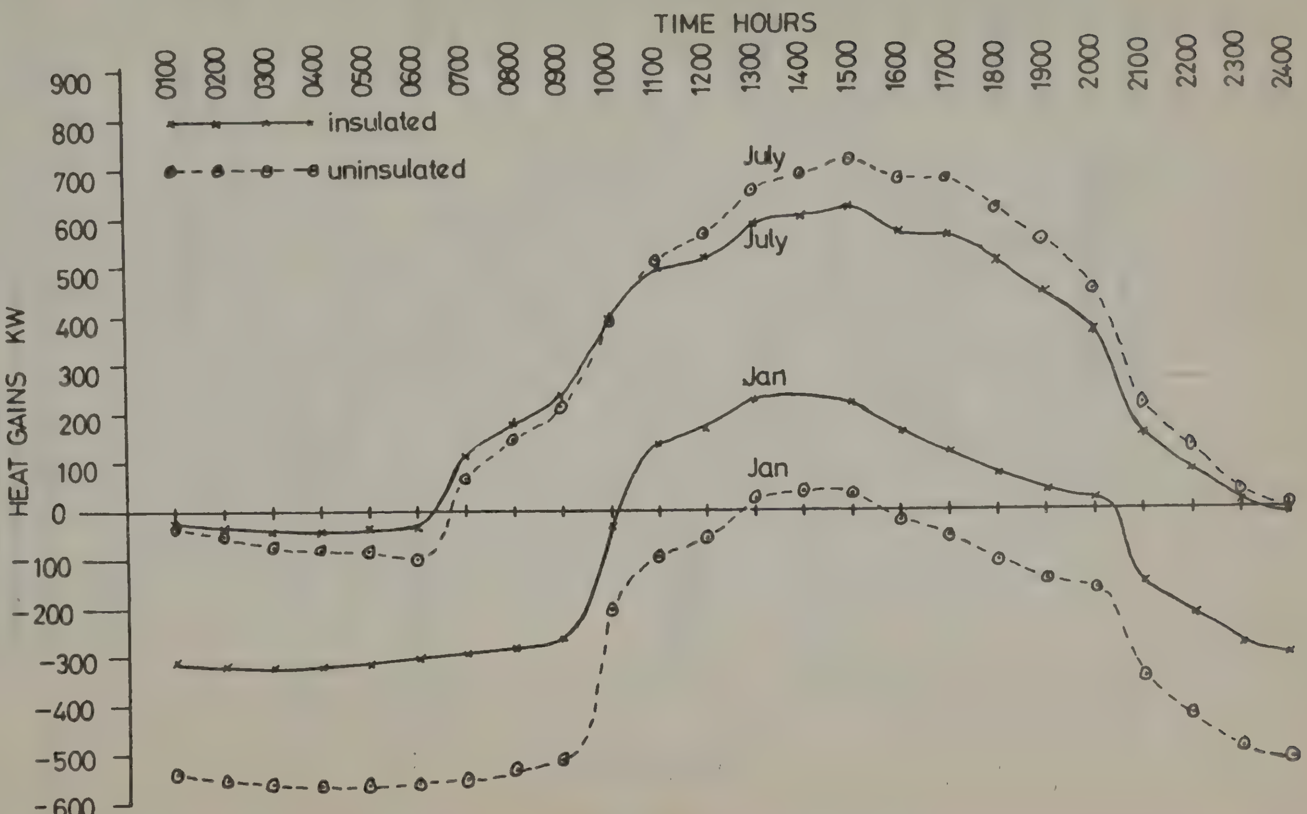


Figure 4 Heat input to maintain a temperature of 20^{0}C throughout typical days in January and July for the uninsulated and insulated buildings.



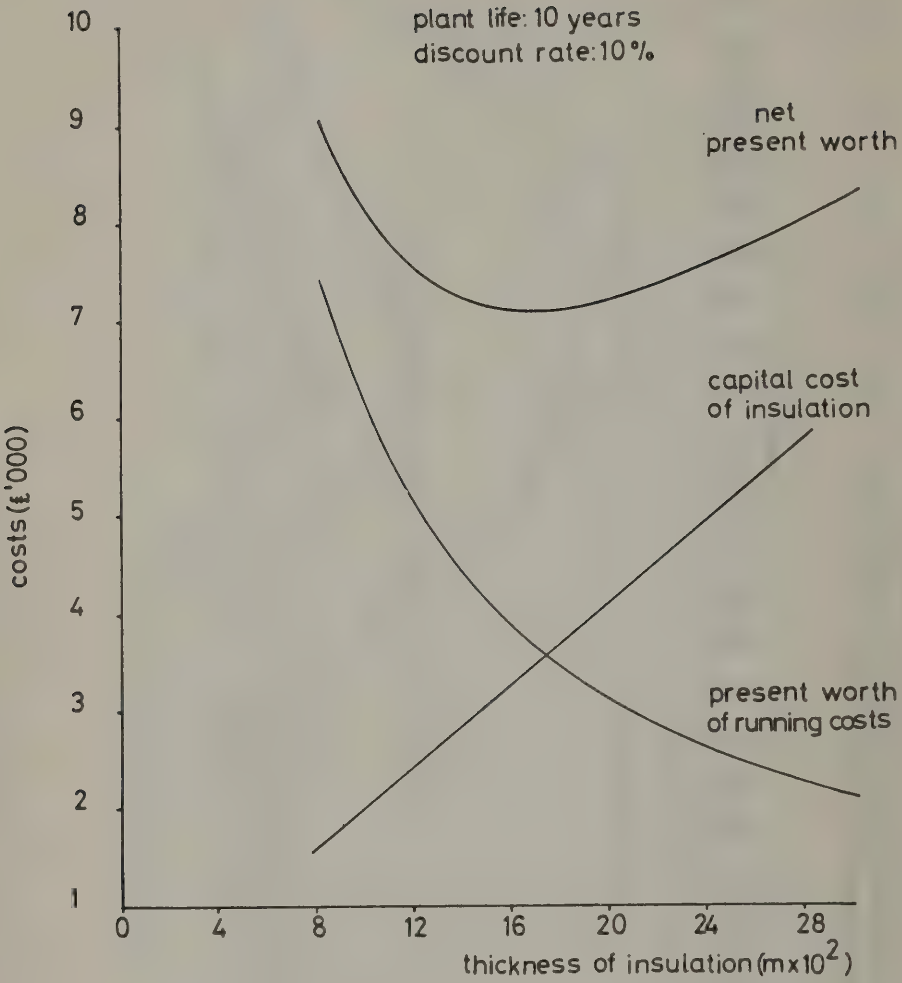


Figure 5 Present worth of capital and operating costs of an ageing oven for varying thicknesses of insulation. Discount rate 30%.

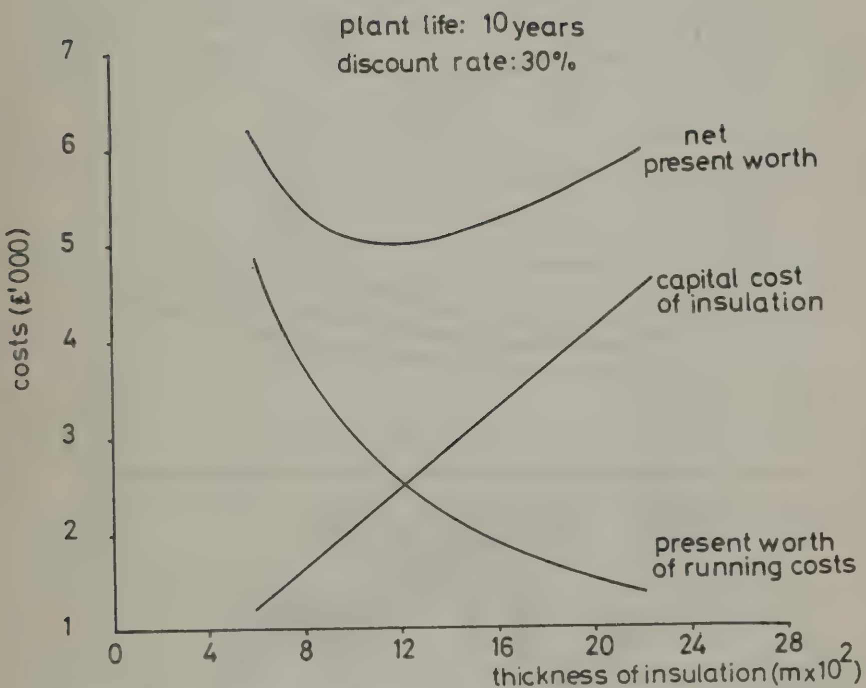


Figure 6 As Figure 5, discount rate 10%.

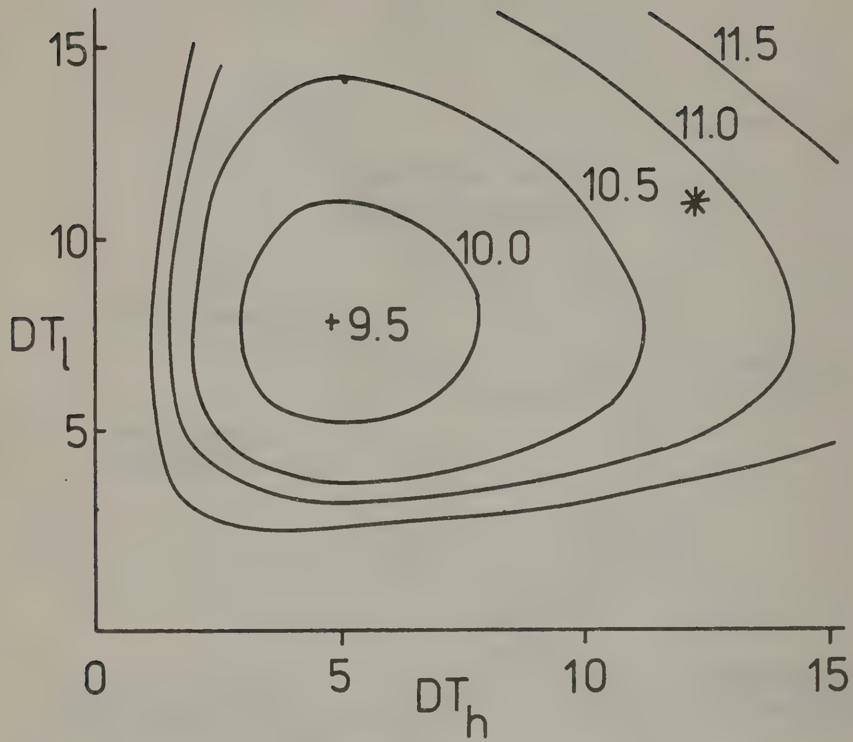


Figure 7 Contours of the present worth of buying and operating refrigeration plant with varying heat exchanger sizes on the evaporator and condensor.

Present worth contours in £000's.
Refrigeration load = 100 kW
Load factor = 0.5
Optimum DT_L = 8°C
DT_H = 5°C

Energy savings due to operating at the optimum design is 26%.

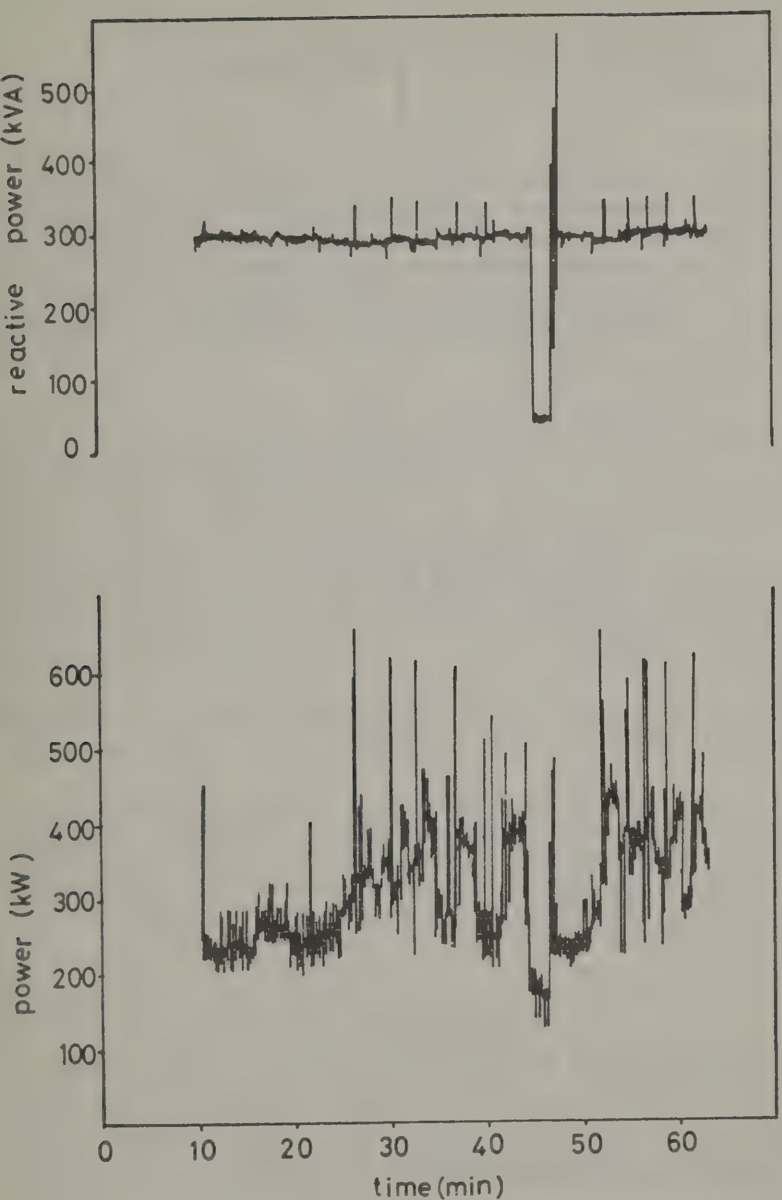


Figure 8   Power and kVAr record of an aluminium extrusion press.

APPENDIX

A REVIEW OF GOVERNMENT POLICY FOR ENERGY CONSERVATION IN THE UNITED KINGDOM

Energy conservation policy in the U.K. has so far relied essentially on the voluntary response of individual corporate and domestic consumers to a combination of higher prices, practical advice, information and exhortation and latterly investment incentives. It has been underpinned by a strong promotional campaign - the "Save It" campaign - which has concentrated on the industrial and domestic sectors but is now to pay more attention to the motorist. This campaign has been extensively researched to monitor its effectiveness.

It is extremely difficult to measure the effectiveness of the Government's overall energy conservation campaign, let alone particular aspects of it such as higher prices and the "Save It" campaign. The Government estimates that in 1975 and 1976 savings of some 6 per cent were achieved after allowing for the level of economic activity and temperature variations. The value of the savings achieved in 1974-77 inclusive may have been worth some £2,000 million, measured in terms of the oil which would otherwise have had to be imported.

The history of Government policy can be divided into four phases 1974; 1975-76; 1977; and 1978 to date.

For a period up to 1974 the price of indigenous fuels had been held down artificially to help contain the inflation rate. The incoming Government recognised that this could not continue and that energy prices should reflect more closely the costs of production. This led to steep increases in the prices of fuels and electricity.

The Government made it clear that its policy was to encourage only those energy saving measures which were cost effective. At the same time it recognised that an energy conservation campaign was not a short-term policy. The programme to encourage the efficient use of energy must be sustained in the face of forecasts that the availability of energy would decline and prices continue to rise as world demand for limited resource increased.

The National Economic Development Office - the professional staff of a national forum for economic consultations between Government, management and trade unions - and the Central Policy Review Staff -

the Government's so-called "Think Tank" - published papers recommending future action on energy conservation. The Government also established an Advisory Council on Energy Conservation to advise the Secretary of State for Energy on the development of energy conservation policies.

At the end of the year the Secretary of State for Energy announced a package of 12 measures to promote energy conservation. This was a mixture of incentives, legal compulsion, advice, information and exhortation. It is interesting to note that since then the compulsory element of the policy has been diluted with the relaxing of speed limits in 1974 and the replacement of restrictions on the illumination of display signs in daylight hours by a voluntary code.

The period 1975-76 was characterised by steeply rising prices, a highly visible publicity campaign and a deeper evaluation of an energy conservation strategy.

The "Save It" campaign was launched in January to promote a greater awareness of the need for energy conservation in all walks of life and to provide practical advice and information on how to save energy. The campaign is seen as a long-term exercise to influence public attitudes and behaviour and is being maintained. It has employed television advertising, leaflets, films and radio tapes and cost some £8m over the period 1975 - March 1978. The Government has set aside roughly £2m a year for the next three years to maintain the campaign.

In July 1975 the Select Cqmmittee on Science and Technology and the Advisory Council on Energy Conservation published reports containing some 40-50 recommendations for action. These recommendations came at a time of severe economic stringency and this was pointed out in the Government's Reply to the Select Committee's report. The Reply, published in the form of a White Paper, also took into account the Advisory Council's report. It identified seven "appropriate" roles for Government.

- ensuring that energy prices reflect at least the costs of supply;
- information and motivation;
- setting a good example in the public sector;
- ensuring the availability of specialised advice and training;
- research and development;
- promoting standards and codes of practice relevant to energy conservation;
- imposing mandatory measures.

Energy managers' groups in different areas developed rapidly. These are designed to provide managers who have specific responsibility for energy management in industry, commerce and public authorities with a local forum for discussion, pooling of ideas and mutual support. At the first National Energy Managers' Conference, held in Birmingham in September, the Secretary of State for Energy announced a series of new measures to promote energy conservation in industry.

In December the Secretary of State for Energy brought forward a major package of measures on behalf of the Government costing £320m over the first four years. The measures are aimed primarily at improving the efficiency with which energy is used in the public sector. They involve bringing some 2 million local authority houses up to a basic standard of insulation and improving energy use in public buildings, offices, schools and hospitals. It was made clear that these measures designed to achieve savings after 10 years of 10m tons of oil, worth £700m a year at present day prices, were only part of a continuing programme and that further measures would be announced as and when necessary.

Two further measures were announced in the Budget Statement of April 11, 1978. These provide for a selective investment incentive scheme for industry and legislation to bring in before next winter a grant scheme to help private householders, including landlords, to insulate dwelling houses.

Earlier in the year the Government issued a Green Paper on energy policy. Its forecasts assume a saving by the year 2000 of 20% of final energy consumption, roughly equivalent to 100m tons of coal. The Green Paper contains a chapter on energy conservation which indicates that a more vigorous energy conservation policy means that pricing policy, financial incentives and mandatory measures have to be considered seriously.

Research and development strategy is under review. As world energy prices rise it will become cost effective to introduce new energy efficient technology. A new programme of demonstration projects, provided for in the December 1977 statement, is being implemented to show industry the benefits of investment in energy efficient technology.

This review is compiled from information supplied by the Energy Conservation Division. I am most grateful to them for their generous help.

NATIONAL SOCIETY FOR CLEAN AIR

45th ANNUAL CONFERENCE
2-5 OCTOBER 1978
BRIGHTON

THE ECONOMICS OF CLEAN AIR

by

Julian Lowe,
University of Bath

136 North Street
Brighton BN1 1RG
England

INTRODUCTION

The role of economists in the investigation of environmental problems and their control has been substantial. They have been integrated into agencies concerned with environmental protection in various countries. Their most significant government backed use has been in the United States Environmental Protection Agency (EPA) where Section 312(a) of the Clean Air Act amendments of 1970 requires an annual report on the prospective costs and impacts of governmental and private efforts to carry out the provisions of the Act. In the U.S.A. national cost estimates are presented for governmental programmes as well as those for the control of major sources of air pollution. For this purpose the sources of air pollution are broadly divided into three major categories: transportation sources, industrial sources and sources related to stationary fossil fuel consumption. Coverage includes not only those pollutants for which national ambient air quality standards have been specified, but also pollutants covered by proposed hazardous air pollutant emission standards and by new source performance standards. The EPA commissioned a large number of internal and external consultants to evaluate the costs of clean air and the likely impact on industry, individual firms, prices and employment, of the associated environmental programmes, all of these being published and publicly available. In the U.K. it was recommended that more economists became involved in developing environmental regulations but as yet there has not been activity on the scale of that in the U.S. In a European context the O.E.C.D. published a study of control costs in certain industries in 1973 and since then has recently published some further research into control costs and their economic impact in the Primary Aluminium, Iron and Steel, Pulp and Paper and Fertiliser industries.

The reason for this flurry of activity was of course the clear need for government decision makers to evaluate existing and future environmental policies in the light of information about the impact of controls on industry and also to promote access to and the use of information for a proper and informed public debate on the central issue of what amounts to 'how much pollution is good for us?'

Clearly a total elimination of all airborne residuals is technologically impossible and it is possible that further control from existing levels may also not be economically justifiable. To answer the question of 'how much pollution control?', thus demands substantial inputs of information both on the primary and secondary costs of control and on the primary and secondary impacts of

the control on the environment. Ultimately some trade - off must be made between those who benifit from less pollution, and those who suffer from the cost-inflation impact of environmental control and prices and employment.

To answer these questions we need information on the benifits and costs of pollution control <u>over a large range of policy options.</u> This paper attempts to identify some of the key issues involved and in particular pin-points some of the more salient features of evaluating the costs of protecting the environment.

THE MEASUREMENT OF POLLUTION AND ITS CONTROL

Investigating pollution and the benifits/costs and its control can present some substantial problems. There is little universal agreement as to what constitutes a pollutant, since as scientific research is being undertaken continuously, and the world's markets for resources change, our understanding of when a pollutant is bad and when it is merely a valuable by-product of the production process is constantly changing. Medical research also changes our understanding of the harm caused by wastes dispersed to the land, atmosphere, or water courses. The sulpher dioxide emissions from primary metal melting are used to manufacture sulphuric acid, wastes from whisky distilling are used as animal feeds, and the beneficial flushing effect of dyeing effluent on the sewage has been recognised by some local authorities such that there is sometimes a zero price levied for its discharge.(1)

Our understanding of the harm done by certain substances that build up over time to toxic levels (like DDT) is necessarily a slow process. Also it is possible that controls are based not on known coefficients concerning output of pollutants and harm done to the environment but by the risk of averse conjectures of central and local government agencies, who in the past have sometimes been accused of basing their control policy strategy on the latest crisis or scare in a related but difficult situation; for instance the Deposit of Poisonous Wates Act 1972 passed through Parliament in 22 days following sustained media pressure concerning some cases of dangerous tipping.(2)

In this sort of situation it may sometimes seem to the impartial observer that public decision makers are not particularly clear about the right strategy to take and consequently environmental control proceeds on an <u>ad hoc</u> basis. To reinforce this, one has to look no further than the governments attitude to lead in the air, where the lead industry has been subjected to very stringent controls and where other metal melters who in pre-treatment also

emit lead compounds to the atmosphere have been controlled less, and where the major lead polluter - car exhausts - seems safe as long as the British car industry can continue to plead about the consequences of the necessary increased costs for their share of the U.K. market.

BENEFIT-COST ANALYSIS AND ENVIRONMENTAL CONTROL

Estimating Benefits

In a free society environmental control should clearly be continued to that point where the incremental benefits of improving the environment is just equal to the incremental cost. This rather bland decision rule omits important issues concerning income distribution and 'fairness' but does at least provide some starting point for analysis.

The methodology of estimating the benefits of environmental control is outside the scope of this paper but it can be noted that benefit estimation must in part be subjective; reductions of various pollutant loads can be measured but the impact this has on society can only be conjectured since the intangibles on the benefit side of pollution control are substantial and highly variable. The expectations, knowledge and awareness of those impacted are crucial factors in any evaluation; for instance research on the effects of stricter smokeless zones in Sheffield[3] suggested that the number of public complaints concerning air pollution <u>increased</u> as the quality of the air became <u>cleaner</u> since the public <u>expectations</u> of what this quality should be had also changed.

Other research found that it was common for most of the complaints to local authorities concerning industrial pollution to come from new residents to an area [4] (who were probably aware of the hazards when they moved). Attempts at social benefit cost calculations have been made by looking at pecuniary factors such as property values, but more often than not the results have been an inadequate guide - as the government's evaluation of the Roskill Commission on the third London airport showed. However, in addition to these major methodological problems there is a further difficulty when evaluating the benefits of environmental control, (and thus the guidelines for the optimum investment in pollution prevention). It is the problem of ensuring that control does not merely switch the damage from one environmental medium to another. The fifth report of the Royal Commission on Environmental Pollution found this to be potentially serious in specific areas and recent research in the U.S. has shown that the sulphur dioxide and fly

ash generated by the electricity used to power pollution control equipment is sometimes more of a pollution hazard than the pollution it is trying to prevent.

In spite of these problems attempts are made to value various environmental goods and it is reasonable to do this although the pitfalls of measurement must be stated. For those interested, an evaluation of the practical problems involved is given by D.W.Pearce in a recent article.(5)

The traditional cost-benefit approach really falls at the fence involving the technical difficulty of predicting the physical effects of pollutants and the lack of a market determined price at which to calue environmental goods. An alternative to cardinal measurement of benefits has been developed by the Battelle Collumbus laboratories which utilizes the concept of subjectively determined environmental index.(6) Their approach was to develop two levels of weights, the first for different pollutants within the same media and the second for comparing damage to alternative media. These weights are then multiplied together to attain an overall weight for a particular pollutant. This weight was then subjected to an exogenously determined modifier to take account of the characteristics of each pollutant in terms of its persistence, its geographical range of impact and its transferability between media.

The volumes for all emissions were then applied to an arbitrarily determined 'S' shaped damage function based on increasing outputs of the pollutant. A damage index between 0 and 1 was obtained for each pollutant according to total emissions. This was then multiplied by a weight appropriate to the particular pollutant. The development of the weights was achieved by using a modified 'Delphi Technique'. A panel of experts was engaged to rank a list of pollutants and then to rate the second as a fraction in importance of the first, the third of the second and so on. This process was repeated separately for the range of emissions for each industry using the 'S' shaped damage function to aid the evaluation at different levels of output of each emission. After the results of this first stage were recorded each member of the panel was sent a copy of the median ranking of all experts and given the opportunity to amend his previously stated views in the light of this information. The iterative process was continued until sufficient consensus was attained.

There are many problems involved with this procedure, mainly concerning the arbitary nature of the 'S' shaped damage function and the use of a modifier. However the general thrust of benefit

evaluation in terms of the subjective evaluation of experts attaining consensus is likely to be a rewarding one, and makes considerable sense when there are few reliable economic measures of pollution damage and when environmental goods are rarely traded. The fact that there is often disagreement between chemists, biologists and medical practitioners about the impact of pollutants supports rather than detracts from this form of approach.

Estimating Costs

Control cost evaluation may also be ambiguous, although it does not present the same problems as benefit appraisal. Essentially there are basically two types of pollution control; the first may be described as the short-run palliative which can often be added on to the production process either at the planning stage or retrospectively, frequently described as "end-of-line pollution control". This type of device includes, say, filtration plant used to clean exhaust gases before being discharged through a chimney. Whilst no change in the inputs (physical or capital) for the production process is involved, equipment is added to the end of the production line to control the discharge of pollutants to the atmosphere.

Generally, computing the costs to the firms of the various types of equipment is relatively straightforward. What cannot be costed, however, are the various "intangibles" involved:- the "cost" of lost production as the equipment is being installed, the opportunity of an alternative allocation of capital expenditure on productive plant and the opportunity cost of the physical space taken up by the control device. Quantification of this type of data is difficult but a subjective impression would be that in some cases they may be substantial and a simple totting up of the tangibles can seriously underestimate the full cost of pollution control. In addition the size of firm may be important in evaluating the eventual cost of control - a small firm may lack the necessary expertise or not have its own internal resources to design control equipment and will consequently have to reply upon outside consultants or manufacturers, in which case pollution control will cost more than if the firm had been able to deal with the problem itself.

However, accepting the whole part of the end-of-line pollution control cost may also be misleading if the equipment brings benefits to the firm. Filtration plant, for example, can permit captured materials to be recycled and frequently in areas (such as non-ferrous metallurgy) where raw material costs are very

high, this may be essential to ensure the economic viability of the process. In raw wool processing, removal of grease and other impurities from the wool is essential and the discharge of the resulting effluent without treatment would be wholly uneconomic. Here the ability to sell the lanolin so produced at approximately £400 per ton more than compensates for the cost of its removal.(7) Allocating the whole cost to pollution control would clearly be wrong as would allocating the whole benefit (when there is a net benefit). The "correct" cost to be allocated to pollution control is that involved for pollution control levels over and above those that would be undertaken solely for "economic" reasons. Some recent research showed that few firms had any idea about what proportion of their wastes they would collect for economic reasons. This may be partly due to the fact that pollution legislation pushed them into recycling when otherwise they may not have considered it.

The second type of pollution control measure is much longer-run in character involving a change in the nature of the inputs to the production process itself. It may mean the use of alternative raw materials processed in existing machinery or existing materials processed in new machinery or a combination of both. A wholly new technology may be introduced to manufacture the product. These changes can be classified as "in-plant" and clearly these measures will frequently be incorporated over a very much longer period of time than the end-of-line control equipment. Thus, the length of time industry is given to clean up its emissions to the environment determines the nature of the control measures the firm is able to undertake and the extent and impact on its costs. We can identify many examples of process substitution which have had an impact upon pollution control; in some cases the move has been prompted by the need for pollution control but in others "economic" and environmental considerations have worked in the same direction. An important example of a process change prompted almost entirely by pollution control considerations, is the now widespread adoption of the so-called "pre-bake" cell in the production of aluminium.(8) This is technically <u>less</u> efficent than other types of cell which have been developed but has the advantage that the waste gases are much more easily cleaned. In this case, pollution control necessitates the acceptance of a technically less efficient production process.

Cost estimation under these conditions is clearly difficult and further process subsitution can lead to changes in the <u>quality</u> of the product which will also be difficult to quantify. This has happened in ferrous founding where the castings produced from electric furnaces are of a much higher quality than those from

the traditional cupolas. In addition, just as there are opportunity costs to the firm of process change, there are opportunity costs to the consumer as well since some products may satisfy consumer needs but their production may be exorbitantly expensive from an environmental point of view.

Costs and the Cost Function: U.S. and European Data

National data is only available for the U.S.A. - largely because of the Environmental Protection Agencies crusading in this direction. Thus below we discuss the nature and importance of U.S. data and then look at industry data generated in the U.K. and Europe.

In the U.S.A. in 1974 (the latest census data available) the size of pollution control expenditures for U.S. industry was considerable as Table 1 below shows and accounts for almost a third of all capital expenditure in some industries. The most recent estimate for total costs was $7.7 billion in 1975.

Table 1. Pollution Control Expenditures in U.S. Industry

Industry Group	New pollution Capital	Control Expenditure Operating Costs (1) $ m	Pollution Control capital expenditure as % of all capital expenditure
Petroleum	462	420.1	29
Paper	477	289	24
Primary metals	647	590	23
Chemicals	539	643	14
Stone,Clay,Glass	209	152	13
Food	199	268	9
Furniture	28	19	7
Leather	3	8	7
Textiles	32	54	4

Source: Pollution Abatement Costs and Expenditure 1974
Bureau of Census 1976

Further data and <u>future</u> costs in order to meet various standards is available in a Senate publication The Cost of Clean Air (9) Table 2, which is extracted from this publication illustrates the very significant amount of U.S. national resources that will be expended to achieve a cleaner airborne environment.

Table 2. Incremental National Costs of Air Pollution Abatement for the period 1975-1979 (millions of dollars)

	Investment			Annualised Costs (per year up to 1979)		
	Expected	Minimum	Maximum	Expected	Minimum	Maximum
Mobile sources	19,810	18,810	19,810	7,382	7,382	7,382
Fossil fuels	6,715	5,123	9,172	6,109	4,117	7,742
Fuel industries	552	469	638	270	197	336
Chemical industries	422	398	476	135	123	147
Metal industries	1,726	1,597	1,865	1,520	1,438	1,629
Burning & incineration	1,213	1,090	1,354	721	639	801
Quarrying etc	256	173	340	265	217	319
Food and forest	2,164	1,876	2,442	494	437	558
Total	32,861	30,539	36,009	16,901	14,552	18,915

Source: The Costs of Clean Air op cit

The expected incremental annualised cost of air pollution control is clearly quite substantial - as of course will be the benefits. However to put it into perspective it represents something approaching 1.7% of U.S. Gross National Product and 500% of their foreign aid programme.

The costs given in the two tables above do not of course tell the full story, firms may go bankrupt, industries will become less competitive internationally and inevitably there will be some decrease in productive employment - unless U.S. industry is so internationally competitive that it can afford to absorb these heavy costs of environmental control.

Similar sort of data is unavailable anywhere else but data on individual industries has recently become available for the U.K. and some O.E.C.D. countries. Some of this data is summarised in Table 3.

There are several aspects of these studies and the data generated which are important. First there is a very high degree of variability even within very specific industries. In part this is because some of the most heavily impacted industries are those which have a mix of modern and old plant, which means the type of control and user needs will vary. Also locations are different and for a variety of economic, environmental, technical and political factors this may affect the costs of control and the

Table 3. Air Pollution Control Costs in the U.K. and O.E.C.D.

Industry	Mean Pollution control costs	Range of pollution control costs	Pollution control costs as % of total costs
Primary Aluminium (1)	N/A	N/A	8 - 10
Secondary aluminium (1)	6.3	3 - 10	5 - 10
Primary and secondary lead (1)	6.5	1 - 16	2 - 10
Secondary copper and brass (1)	3.5	0.6 - 7	N/A
Iron and steel (2)	16	14 - 18	N/A
sintering (2)	N/A	0.3 - 1	N/A
coking (2)	N/A	5 - 8	N/A
raw iron manufacture (2)	N/A	0.5 - 1	N/A
raw steel manufacture (2)	N/A	2 - 14	N/A

(1) £ per tonne 1976

(2) £ per tonne 1972

Sources: Emission Control Costs in the Iron and Steel Industry, OECD 1977

J.Lowe and M.Atkins, The Costs of Pollution Control in the U.K. Non-Ferrous Metals Industry. Metal Bulletin, September 1977

degree of control achieved. As well, the ability of local and central government to police adequately pollution regulations, will have a substantial impact on the extent and nature of control costs.

The size of firm and extent of integration also appear to be a determining factor of control costs since large and/or integrated operations which have substantial head office research resources are frequently better placed to negotiate and implement environmental control. This factor has been reinforced in some recent research which found for instance that the extent of recycling and firm size were closely linked in the Textile Dyeing and Finishing industry. (10)

There is considerable evidence of economics of scale existing in the operation of air pollution control equipment. One major reason for this is that until recently pollution control equipment manufacturers had only been designing equipment for the larger firms. This, coupled with the technological problems faced by small firms, means that environmental control may force small

firms to merge or go out of business altogether. For instance in ferrous founding the cost per unit of output of using a high energy scrubber to clean dusty gases falls from £2.50 per unit of output for a 2 ton per hour cupola to £1.50 per unit for a 10 ton per hour cupola and to £1.00 per ton for a 30 ton per hour cupola.[11] A similar picture emerges in the Iron and Steel industry where, according to a recent source, measures for controlling airborne emissions from new steel furnaces would generate economics of scale of 25% - i.e. a 100% increase in the unit cost of operation would lead to a 25% fall in unit treatment costs.[12]

However perhaps the most important aspect of costs is the marginal cost function, i.e. the incremental cost of achieving higher degree of pollution control. Here recent research[13] shows that control at levels much higher than at present, may in some industries lead to very substantial cost increases. One example quoted was in secondary lead processing where it was estimated that for an average plant the total cost of control per tonne of lead produced increased from £2 per tonne at 95% collection efficiency, to £4 per tonne at 99%, to £8 per tonne at 99.8% and £10 per tonne at 99.9%.[14] According to another report in primary aluminium the change from 94% overall control efficiency to 95% with current technological alternatives would double the costs of control.[15] These two industries are dominated by very large firms or firms which are members of large groups and consequently in the short-run at least it is unlikely that closures will result. However in other industries like the iron founding industry where there are many more small/independent firms it is less likely that industry structure will be unscathed.

The costs of control considered are of course those that are accounted for by the polluter and ultimately by his customers, shareholders and employees. It should not however be forgotten that since it is impossible to get rid of pollution[16] then air pollution control may merely be transferring the problem to another environmental media; thus air pollution control has some clear secondary impacts on these other media. This reinforces the need for more research into the social costs and benefits of pollution control. What is essential is that the different damage done to varying aspects of the environment through the alternative control strategies is better understood; the achievement of this may not be a greater number of technologists expert in the pollution control as a recent report has suggested[17] but rather an expanded agency with economic, social <u>and</u> technical knowledge of alternative pollution control strategies.

CONCLUSION

Clean iar must be paid for; the question remaining is how far should the policy of environmental improvement be extended. This paper has attempted to spell out the sort of economic imformation that would be needed to make adequate choices whilst at the same time identifying some already important factors that have arisen.

With steeply rising marginal costs of emission control this may well mean that optimum environmental standards have already been achieved in some industries, or at least that the greatest environmetal benefit may be generated by looking at some industries that have come under less scrutiny than others in recent years. The problem of course may be self righting since during times of increasing commodity prices recycling and resource conservation may be congruent with pollution regulation. However public policy can best proceed if (a) the government continally monitors (b) adopts the concept of a unified control agency, (c) resists pressure to adopt single emission standards and continues with a policy of best practicable means coupled with uniform environmental standards, and (d) - perhaps most importantly - makes all information freely available so that proper public debate is possible, since above all the concept of optimum levels of control must ultimately rest on value judgements concerning society's trade off between production and environmental goods.

REFERENCES

(1) M.H.Atkins and J.F.Lowe. Pollution Control Costs in Industry: An Economic Study Pergamon Press 1977

(2) A.Kniber, B.Richardson and R.Brookes 'Deposit of Poisonous Wastes Act 1972' Government by Reaction? Public Law 1974

(3) G.Wall. 'Air Pollution in Sheffield' International Journal of Environmental Studies. 1974 Vol 5.

(4) M.H.Atkins and J.F.Lowe op cit 1977

(5) D.W.Pearce. 'The Limits of Cost - Benefit Analysis as a guide to Environmental Policy'. Kyklos 1976

(6) Battelle Columbus Laboratories. 'Final Report on the Development of Cross-Media Evaluation Methodology' E.P.A. Pub No PB-232-414

(7) M.H.Atkins and J.F.Lowe. Case Studies in Pollution Control in Textile Dyeing and Finishing. Pergamon Press Jan 1979 (forthcoming)

(8) P.M.J.Gray. 'Design Requirements for Emission Control in Non Ferrous Extraction Plants' Engineering Aspects of Pollution Control in the Metals Industry Metals Society 1976

(9) Annual Report of the Administrator of the Environmental Protection Agency 'The Cost of Clean Air'. Senate Document No 93-122 1974

(10) J.F.Lowe and M.H.Atkins. 'Resource Conservation and Environmental Control' Journal of Resources Policy 1978

(11) P.J.Mosely and F.M.Shaw 'The Work of the Cold Blast Cupola Panel of the Grit and Dust Working Party' National Society for Clean Air 1975.

(12) Emission Control Costs in the Iron and Steel Industry O.E.C.D. Paris 1977

(13) J.F.Lowe and M.H.Atkins 'Pollution Control Costs in the U.K. Non Ferrous Metals Industry' Metal Bulletin.September 1977.

(14) J.F.Lowe and M.H.Atkins. ibid 1977

(15) J.F.Lowe and M.H.Atkins. ibid 1977

(16) R.U.Ayres and A.V. Kneese. ' Production Consumption and Externalities' American Economic Review 1969

(17) The Royal Commission on Environmental Pollution 5th Report H.M.S.O. 1976.

NATIONAL SOCIETY FOR CLEAN AIR

45th ANNUAL CONFERENCE
2-5 OCTOBER 1978
BRIGHTON

AIR POLLUTION - THE COST OF ABATEMENT AND CONTROL

by

A.W.F. Maule,
Environmental Health Department,
City of Sheffield

136 North Street
Brighton BN1 1RG
England

The cost of abatement and control of pollution both in the industrial field and the domestic field is extremely high and there are some who might say, has it all been worthwhile? It should be remembered that the high cost of abatement in the industrial field does not necessarily produce any return, for although in many cases efficiency may be raised, production is not always increased nor is the quality of the finished article improved.

Speaking on the anniversary of the notorious 1952 London smog as reported in the Daily Telegraph on the 12th December, 1977 Professor Lawther stated that the total estimated cost of the domestic smoke control programme now stands at £74 million which is small in comparison with the cost of damage which was caused by air pollution per annum.

DOMESTIC SMOKE AND SULPHUR DIOXIDE

As a direct result of the great London smog disaster of 1952 in which over 4,000 people lost their lives, the Government of the day set up the Beaver Committee to investigate all aspects of atmospheric pollution and, as a direct result of their findings, the Clean Air Act of 1956 came into being. In this report the Beaver Committee stated that more than half the smoke pollution came from industrial sources and railways but, for each ton of coal burned, domestic chimneys produced twice as much smoke as industry and discharged it at a much lower level which makes it more serious. The Committee confirmed that sulphur dioxide is produced whenever a sulphur bearing fuel is burned and, as coal was the chief fuel in the domestic field, domestic chimneys were responsible for a large part of pollution of this nature.

The Clean Air Act of 1956 was a great step forward in the fight against atmospheric pollution as it gave Local Authorities more power to deal with the problem and for the very first time it provided control over domestic chimneys, allowing Councils to declare smoke control areas in their districts.

Sheffield, prior to the re-organisation of Local Government which took place on April 1st, 1974 was a large City with a population of 513,310 a total area of 45,363 acres and it contained 189,000 houses. The domestic smoke control programme in Sheffield commenced 19 years ago when our No. 1 (Central) Area became effective on the 1st December, 1959. In all, 27 smoke control areas were declared and 99,070 houses had appliances for heating and cooking converted to smokeless conditions. Grants paid to

owners or owner/occupiers of property amounted to £2,344,894 and the programme was completed on the 1st December, 1972.

Bearing in mind the fact that the above mentioned figure represents the seven tenths grant paid to owners and owner/occupiers, a further £1,004,955 has to be added to the total, this being the contribution paid by the owners or occupiers themselves. Whilst the smoke control programme was in progress, a staff of 20 people were employed including survey assistants, supervisory and clerical staff and their salaries amounted to £260,000. Adding all these figures together, a final total of £3,609,849 is reached which is the expenditure on the Sheffield domestic smoke control programme.

Houses due for demolition have to be considered and where a house has an expected life of 5 years or less, no conversions are carried out and it is exempted from the smoke control order.

New houses built on or after the 16th August, 1964 are not eligible for grant as they are supposed to be provided with smokeless appliances for heating and cooking purposes.

It should be remembered that the domestic programme has played a major part in the reduction of pollution both from smoke and sulphur dioxide in the City. From our statistics, 75% of the public have converted to gas fired appliances and, as natural gas is virtually free from sulphur, this has been most beneficial.

INDUSTRIAL POLLUTION

On the 1st June, 1958 when the Clean Air Act 1956 became fully operative, there were many hand fired furnaces and boilers burning coal still in existence throughout the whole country. Industry in the United Kingdom covers a vast field and includes such undertakings as woollen mills, cotton mills, flour mills, breweries, hospitals, bakeries and confectionery, the chemical industry, the steel industry, railways, coal mines and power stations.

For practical reasons this part of the paper deals with industrial pollution and the cost of its abatement and control from the steel industry, coal mines, railways, power stations and the gas industry.

STEEL INDUSTRY

In Sheffield there were hand fired furnaces burning coal operating on June 1st, 1958 within the local steel industry. These furnaces included re-heating furnaces, annealing furnaces, heat treatment furnaces of all kinds and soaking pits; many of the furnaces were

rough and ready appliances with little or no control over combustion and some were equipped with a forced draught fan. All these hand fired furnaces emitted large volumes of black smoke frequently as it is extremely difficult to fire a furnace or boiler by hand with coal without making an appreciable amount of smoke.

There were also many heat treatment and metling furnaces used by the steel industry in the area which were fired by raw producer gas. Producer gas is an unclean gas, it contains an appreciable amount of tar in suspension, and this tar adheres to the inside of pipes and valve chests and to the bearing surfaces of valves and seats. This deposit of tar had to be got rid of and the method used was burning off which entails setting a light to the tar in the pipeline which produces clouds of filthy black smoke. Burning off was carried out at regular weekly intervals.

A large steelworks within the private sector in Sheffield undertook a conversion programme between 1956 and 1977 and, during that period of time, a total number of 45 furnaces were converted from coal firing or producer gas firing to gas firing. In 1956 this Company spent £30,000 converting some of their furnaces from hand fired coal burning to gas whilst in 1957 £45,000 was spent and in 1959 a further £660,000 was spent for this purpose. In 1960 the Company spent £180,000 in order to replace their coal burning locomotives with diesel and in 1962 a further £250,000 was spent in converting more of their hand fired furnaces and producer gas fired furnaces to gas. In 1963 the Company spent a further £220,000 converting the remainder of their producer gas fired furnaces to gas. In 1968 £100,000 was spent by the Company for converting mechanically stoked coal burning furnaces to gas whilst in 1977 a further £30,000 was spent for this purpose.

If all these figures are added up the total amount of money spent by this one firm between 1956 and 1977 on converting furnaces and locomotives amounts to £1,515,000 but this amount is not all on the debit side for old antiquated plant was being replaced by modern appliances and therefore the overall efficiency must have improved.

Reddish brown fume emissions of oxides of iron from steel melting furnaces using oxygen has been a serious problem for some considerable time.

A large steelworks within the public sector in the Sheffield area between 1962 and 1965 replaced 21 open hearth furnaces with six 135 ton electric arc furnaces in their melting shop. All these furnaces were provided with wet electrostatic precipitators

complete with integral combustion chamber and conditioning tower, and large aerofoil fans with variable speed control. A 90ft. chimney stack was provided for each cleansing plant together with water and effluent plant comprising pumps and centrifuges for removing thickened sludge for disposal to the tip.

The original fume arrestment plant and effluent treatment plant for these furnaces cost £912,000. Over a further period of eight years more money was spent on improving the plant as follows:-

Modifications to precipitators, independent electrical supplies to fields, new combustion chambers and extensions to conditioning towers, extensions to water and effluent plant £200,000. Replacement of filters with rotary vacuum filter £30,000. Third field precipitators to two furnaces £459,000. Two furnaces were removed to another plant in the area and their precipitators were connected up in series to the two remaining furnaces at a further cost of £139,000. Totalling up these figures it will be seen that from 1962 to 1973 £1,740,000 was spent on fume arrestment plant for this particular melting shop.

The operating costs per week for this plant were calculated during 1972 as follows:-

Labour	£ 860
Services - Power and Water	£2370
Maintenance - Engineers and Bricklaying	£2760
Special Repairs	£ 770
Depreciation	£1750
Total	£8510

Over the years it has been found that a straight filter bag unit, an electrostatic precipitator or a wet scrubber, is not sufficient to arrest the fume satisfactorily from an electric arc furnace for when the furnace is being both charged and tapped, the fume arrestment plant has to be uncoupled in order to allow the furnace lid to open or the furnace itself to tilt and so some extra form of extraction is required.

At this melting shop a roof extraction plant discharging into a large filter bag house was commissioned during 1975 at a further cost of £3,000,000. In order to collect the fume rising from the furnaces during charging and melting, a hood 28 metres long by 15 metres wide was provided for each furnace by partitioning off the roof above. Similarly in the casting bay, a hood of the same size

was provided to collect fume arising during tapping. For the full length of each hood, the jack roof ventilator at the apex was replaced by an extraction duct. The collection ducts from the hoods serving two adjacent furnaces were connected into a transverse duct a damper being provided at each connection. The transverse ducts from the furnaces and casting bay carry the fume to the fan manifold from which it is extracted by five 1,600 horse power induced draught fans having a combined capacity of 45,075 cubic metres per minute at normal temperature and pressure. The induced draught fans deliver the fume to a bag filter plant and from there the dust is collected in hoppers underneath the filter plant which are emptied automatically by a system of drag link conveyors into a common storage hopper for disposal.

Another Company in the private sector installed a new 100 ton electric arc furnace in their melting shop in 1975 complete with combined direct extraction from the furnace and roof extraction discharging into large filter bag units. Fume is extracted directly from the furnace through a water cooled elbow and passing through a burner duct before entering the combustion chamber. As well as acting as a safety device by burning away combustible gases in the fume, the combustion chamber also serves to collect heavy fume burden drawn from the furnace which falls out into the base of the chamber. The gases are then cooled by passing through a water cooled duct and are then fed vertically into the main overhead canopy duct at the mixing point. The large canopies or hoods situated over the furnace and tapping bay extract fumes during charging and tapping operations. The furnace canopy also provides ventilation for the shop during melting and oxygen lancing operations. Air from the shop together with escaping fume from the furnace are utilised to dilute and cool the hot gases drawn directly from the furnace before they pass into the filter bag house. The fume from the canopies and furnace together with air from the shop are drawn through the ducts to the bag filter house by two 1500 horse power fans. The fume laden gases pass through the bags to atmosphere leaving the solid matter in the bags. In all there are eight bag house compartments each containing 240 bags of 298 m.m. diameter, 11 metres long made of terylene.

Cleansing of the filter bags is achieved by a reverse air process with each compartment of bags being taken off stream in sequence. After this reverse air cycle there is a one minute time lag with the bags completely isolated from pressure to ensure settlement of all solid particles into the collecting hoppers. The dust is then conveyed to a storage hopper for disposal by means of a screw conveyor.

The capital cost of this dry bag system was £1.1 million which amounted to 25% of the cost of the whole installation which included scrap yard modification, furnace, melting shop, ingot transfer facilities etc. The operating costs of this system are £5,829 per week which adds £2.62 per ingot tonne to the price of the steel produced.

Another firm in the public sector which has two 140 tons electric arc furnaces equipped with electrostatic precipitators installed additional roof extraction for their melting shop during 1977. This particular works lies in a valley and, owing to the contours of the surrounding land and the nearby residential property, special acoustic enclosures have had to be provided for the fans in order to reduce noise at an additional cost of £⅓ million over and above the cost of the extraction plant.

It should be remembered that the arrestment and collection of ferrous oxide fumes from steel melting furnaces does not improve efficiency, production is not increased nor is the quality of the finished product improved but these measures are necessary in order to improve environmental conditions.

COLLIERIES

Before the days of electrification in the coal mines, the winding mechanism was powered by large steam engines usually supplied with steam from Lancashire boilers. In some pits there were as many as 16 Lancashire boilers, all hand fired, using natural draught and burning wet slurry from the coal washers as fuel, all discharging into perhaps two tall chimney stacks. It does not take much imagination to realise that a large batch of hand fired Lancashire boilers burning wet slurry is bound to emit large volumes of black smoke which, of course, created a serious pollution problem.

Electrification schemes commenced in the coal mining industry throughout the country during the 1950's and were primarily inaugurated in order to reduce costs and improve efficiency as both the costs of labour and maintenance are much higher when winding is done by steam.

In the South Yorkshire area there are 19 collieries whose output of coal range from 200,000 tons to 1,000,000 tons per annum. In this area electrification commenced in the late 1950's, and was completed in 1974. During this period each colliery which had two steam winding engines, was provided with electric ones and the current cost of the conversion is £300,000 per engine. Taking inflation into account the total cost of electrifying the 19 pits

in the area amounted to £7,600,000 for approximately a 20 year period.

Smoke, fumes and unpleasant odours were often discharged from colliery spoilheaps which caught fire through spontaneous combustion. By careful and controlled tipping and by consolidation using bulldozers and scrapers together with inert material, pollution from tips is not so serious as it once was. At present many colliery spoilheaps are being re-graded and re-profiled and all combustible material is being removed. Eventually some of these tips which are no longer used will be grassed over and used as public open spaces or for agricultural purposes. It is difficult to assess the cost of these operations but, at present day prices, a bulldozer of 120 horse power will cost £18,000 whilst a machine of 220 horse power will cost £25,000; scrapers are also used and they cost approximately £50,000 each. It should be borne in mind that in addition to the initial cost of the equipment labour, maintenance, depreciation and fuel has to be added which are all considerable.

For heating of office premises, domestic hot water and pit head baths, modern economic or package boilers are used and they are either fired by coal mechanically stoked or they burn methane gas drained from the pit. Some collieries are now equipped to generate their own electricity using engines running on drained methane gas from the pit which are convertible to diesel oil during fluctuations of gas supply and demand.

Although these various schemes in the coal mining industry throughout the country have been carried out in order to improve effiency, they have had a most beneficial affect upon the environment by reducing pollution.

RAILWAYS

In their final report the Beaver Committee stated that, when railway locomotives were powered by steam fired by coal, they were responsible for over one-seventh of all the smoke discharged to the atmosphere in Britain. Most of this smoke and grit was emitted from shunting engines and stationary locomotives and it occurred mainly in the vicinity of railway stations, engine sheds and marshalling yards. The Committee added that the only complete answer to the problem would be the replacement of coal fired locomotives by electric, diesel and other smokeless methods of traction.

Of course this problem was encountered throughout the whole country

but in Sheffield we did have large locomotive sheds situated in a wholly residential area. Sometimes there were as many as 50 locomotives standing in these sheds, many of which at any given time were lighting up from cold or raising steam and the smoke which was emitted from this establishment gave rise to many complaints from members of the public.

The modernisation of our railways commenced in 1954, it included the replacement of steam engines by diesel together with the electrification of some lines; the last steam locomotive was taken out of service in 1969. These modernisation schemes were set in motion primarily to improve efficiency and to cut down costs but, of course, they have had a most beneficial effect upon the environment. Steam locomotives have a lower overall efficiency than diesel or electric locomotives and more labour has to be employed for such operations as lighting up from cold, raising steam and cleaning out the smoke tubes in boilers which had to be done regularly.

Some estimated approximate costs at present day prices are given as follows:-

Diesel locomotive for passenger branch line	£550,000
Express diesel locomotive for passenger and freight purposes	£650,000
Large steam locomotive	£350,000
Electric locomotive for passenger and heavy freight	£500,000
Electrification per single track mile inclusive of modifications to bridges and to telecommunications circuits etc.	£ 90,000

The above figures give some idea what the British Railway Board have spent in connection with their modernisation schemes in order to improve efficiency. They deserve their rightful place in the history of the campaign against atmospheric pollution in our country.

POWER STATIONS

The Central Electricity Generating Board has certainly played its part towards the reduction of atmospheric pollution throughout the country during the last 25 years or so. For efficiency reasons and in order to cut costs and raise productivity many old, small, generating stations have been replaced by large new stations which are all equipped with modern efficient arresment plants. The two local power stations in Sheffield were a problem insofar as

pollution was concerned and even though one of them had its chimney stacks raised some 25 years ago, it still presented a problem owing to the contour of the surrounding land which rises steeply on one side of the station to a height of 500 ft., there being houses situated upon this land. The other station, in the City was served by 14 Round Iron chimneys which were lower than the two adjacent cooling towers and, as a consequence, the vapour from the towers tended to bring the sulphur dioxide fume from the chimneys down to ground level. As both stations were some 70 years old they were inefficient by modern standards; for instance their boiler pressures and superheat steam temperatures were comparatively low and they had fewer stages of feed water heating than modern stations. The grit arrestors for these stations were not very efficient and to get an idea of their size, each station had a total output of 160 megawatts whereas nowadays each generating set in a modern station can have an output as high as 600 megawatts. The Central Electricity Generating Board closed one of these Sheffield stations in 1975 whilst the other was closed in 1976.

Many of the large new modern stations such as Drax, Eggborough and Ferrybridge 'C', all situated in Yorkshire, burn coal in the form of pulverised fuel. As power stations are registered under the Alkali Act they have to take measures under that Act in order to minimise smoke, grit and dust emissions from their premises and in order to achieve this, modern stations are equipped with efficient electrostatic precipitators together with high chimney stacks.

Drax Power Station near Selby in Yorkshire was commissioned and became operative in 1974. This station contains three boilers rated at 4,450,000 lbs/hr. from feed at 256^{0}C all burning pulverised fuel discharging into a chimney stack 850 ft. high. The chimney embraces three concrete elliptical flues, each flue designed to serve two boilers. The stack is built of reinforced concrete and comprises 40,000 tons of concrete and 3,500 tons of reinforcement. Aircraft warning lights are fitted at 150 ft. intervals, these lights being equally spaced around the periphery at each level. The lights are accessible from platforms which are served by a lift installed in the centre of the chimney. The cost of this chimney was £1,217,000. Eggborough Power Station which is also near Selby has a similar chimney stack 650 ft. high which cost £460,000 whilst Ferrybridge 'C' Power Station near Pontefract has two similar chimneys 650 ft. high which cost £276,000 each; inflation is undoubtedly responsible for the difference in cost.

In order to arrest grit and dust emissions from the boiler plant, all these power stations are provided with three electrostatic precipitators per boiler. At Drax Power Station this installation cost £2,000,000 and running costs are £6 per hour.

At Eggborough and Ferrybridge 'C' the cost of the precipitators were included in the main boiler contract but the running costs are £5 and £3 per hour respectively. It should be borne in mind that these power stations together with the establishments at West Burton, Cottam and High Marnham to name but a few, are situated upon flat ground and, as they are equipped with very high chimneys, the waste products of combustion are discharged at a high level. The older type smaller stations which they replaced either had no grit arrestment provided or they were of an inefficient type and taking all these factors into account there is no doubt that the measures which have been taken by the Board have been a great benefit to the Environment and to the Community.

THE GAS INDUSTRY

With the discovery of natural gas in the North Sea, the old type conventional gas works closed and their passing was not lamented; many of them were sited close to domestic property and they were a serious source of pollution from smoke, sulphur, grit and unpleasant odours.

The conversion to natural gas, both in the domestic and industrial fields has been a major factor towards the further reduction in atmospheric pollution in general as this fuel emits no grit, virtually no sulphur and if burned correctly no smoke.

Exploration in the North Sea commenced in 1962 and continued actively through 1963, 1964 and 1965 at a total cost of £10½ million.

After the survey there was considerable activity in design and construction of drilling platforms. During the 1960's nine of these each costing upwards of £2½ million were ordered from United Kingdom shipyards. At that time, a single platform, fully commissioned and at work cost upwards of £5,000 a day to run. As it may take up to four months to drill and complete a well two miles deep, drilling is an expensive business especially if the well proves to be dry. The conversion of Britain's gas customers came to an end in September, 1977 in Scotland. In all, visits had been made to some 13½ million premises and 35 million appliances were converted.

The operation which began in the East Midlands during May, 1967

cost approximately £600 million. In addition, there was the cost of gas making plant made obsolete prematurely because of natural gas bringing the total bill for the area to about £1,000 million, all of which had to be written off against revenue without any subsidy.

In round figures some 200,000 customers of all kinds were converted in Sheffield at an average cost of £40 each.

CONCLUSION

The domestic Smoke Control programme throughout the country has been most beneficial to the Environment and to the Community as a whole whilst the measures which have been taken by industry during the past 25 years, in some cases to improve efficiency have also improved the overall situation.

To return to the question posed at the beginning of this paper, has it all been worthwhile? When studying the figures for Sheffield over the past 20 years given at the end of this paper which are typical for the whole country, the answer must surely be yes.

Control of smoke emissions and enforcement must of course continue, staffs used in the setting up of smoke control areas can be progressively reduced where they were appointed on a temporary basis but professional staff and scientific advisory staff in research etc. establishments are a necessary part of control, the cost of such activity must continue and this must be necessity be a not inconsiderable item.

On the credit side many things may be counted, e.g. improved environment, reduced bronchial problems, cleaner buildings, fabrics etc. and an improvement in the quality of life. Whilst the economy can provide the money, the pressure to continue must succeed.

Smoke and Sulphur - Microgrammes per cubic metre for all Volumetric Gauges for 1956-1977

Year	Smoke	No. of Gauges	Average per Gauge
1956	2,610	8	326.0
1957	1,990	8	248.7
1958	2,030	8	253.5
1959	2,550	8	318.7
1960	2,170	8	271.2
1961	1,760	8	220.0
1962	1,700	8	212.5
1963	1,472	8	184.0
1964	1,706	10	170.6
1965	1,323	10	132.3
1966	1,084	10	108.4
1967	944	10	94.4
1968	919	10	91.9
1969	788	10	78.8
1970	649	10	64.9
1971	722	10	72.2
1972	475	10	47.5
1973	453	10	45.3
1974	419	12	35.0
1975	498	12	41.5
1976	506	13	39.0
1977	398	13	30.0

Year	Sulphur	No. of Gauges	Average per Gauge
1956	2,280	8	285.0
1957	2,139	8	267.0
1958	2,342	8	292.8
1959	2,153	8	269.2
1960	1,916	8	239.4
1961	1,659	8	207.2
1962	1,748	8	218.5
1963	1,692	8	211.5
1964	1,818	10	181.8
1965	1,542	10	154.2
1966	1,332	10	133.2
1967	1,476	10	147.6
1968	1,587	10	158.7
1969	1,632	10	163.2
1970	1,599	10	159.9
1971	1,609	10	160.9
1972	1,344	10	134.4
1973	1,367	10	136.7
1974	1,264	12	105.3
1975	1,320	12	110.0
1976	1,108	13	85.3
1977	929	13	71.5

REFERENCES

1. The Development of Fume Cleaning Plant at the Templeborough Electric Melting Shop - I.C. Ross.

2. Atmospheric Pollution Control in the Iron and Steel Industry - J.H. Flux.

3. Wet and Dry - A comment on fume extraction plants for Electric Arc Furnaces - D.G. Allen.

4. Developments in fume extraction at Dunford Hadfields Ltd., and Brown Bayley Steels Ltd. - G.F. Smith and P. Critchley.

5. Discussions with Mr. M.S. Shelton, Deputy Director (Administration), National Coal Board, South Yorkshire Area.

6. Correspondence with Mr. R.K. Andrews, British Railways Board, London.

7. Correspondence with Mr. P. Rocke, Central Electricity Generating Board, Harrogate.

8. Correspondence with Mr. O.K. Smyth, East Midlands Gas, Leicester.

9. Natural Gas and Clean Air Sir Kenneth Hutchison.

NATIONAL SOCIETY FOR CLEAN AIR

45TH ANNUAL CONFERENCE
2-5 OCTOBER 1978
BRIGHTON

CLEAN AIR – WAYS AND MEANS

PART 2
DISCUSSIONS

136 NORTH STREET
BRIGHTON BN1 1RG ENGLAND

CONTENTS

* This paper was not included in Part I of the Proceedings but will be found at the end of Part II.

ENERGY AND THE ENVIRONMENT - THE PUBLIC DEBATE

PRESIDENTIAL ADDRESS BY SIR BRIAN FLOWERS, FRS

Madam Deputy Mayor, Ladies and Gentlemen, one of the advantages of wearing two hats, if I may mix a metaphor, is that it allows one to tell the left hand what the right hand is doing. I would like to use the occasion of my Presidential Address to tell the National Society for Clean Air something about the problems which face me in my other guise as Chairman of the new Standing Commission on Energy and Environment.

Our wide-ranging terms of reference are "to advise on the interaction between energy policy and the environment". Since the Commission has only met once you will understand that it is not yet possible for me to give an account of its activities and its conclusions. But the need for this new body, its broad objectives, and some of its problems, are clear enough. They were foreseen with admirable clarity by Lord Nathan in his report of a Working Party set up jointly by the Committee for Environmental Conservation, the Royal Society of Arts, and the Institute of Fuel, published in July 1974 - a Report that has worn singularly well. Its opening sentence reads: "A policy for the development of energy resources must be created in the context of its environmental and social consequences." It goes on to say: "Protection of the environment cannot be separated from the other objects of a policy for energy; the present skirmishing between environmental interests and the energy industries benefits neither side".

Of course, the problem is not a new one as this Society knows very well. In their delightful study of the origins of the Clean Air Act, 1956, which finally removed smog from our cities, Lord Ashby and Dr. Mary Anderson suggest that preparation for the Act began as long ago as 1819 when Parliament appointed a Select Committee to enquire "how far it may be practicable to compel persons using steam engines and furnaces in their different works to erect them in a manner less prejudicial to public health and public comfort". With a wealth of fascinating detail they tell how it took from then until the Great London Smog of 1952, nearly a century and a half, to mobilise public and Parliamentary opinion sufficiently to bring about effective legislation, in spite of innumerable Reports of Committees and Royal Commissions,

pressure groups, abortive Bills, and attempted prosecutions under unsatisfactory legislation before unsympathetic magistrates.

The conclusions of Ashby and Anderson's study of smoke control were threefold. First, there had to be adequate scientific knowledge and a practicable technology. The science was known to Parliament as long ago as 1843: one simply had to achieve complete combustion, which incidentally saved fuel. "The technology, too, was known in principle: for steam furnaces it was a matter of design and efficient stoking; for domestic fires it necessitated the use of closed stoves, common on the Continent, or burning coke or anthracite. But the air was regarded as free ..... and industrialists were not going to spend money on smoke abatement, nor were householders going to give up their cherished cheerful open fire, without compulsion. These were social, not technological obstacles." In passing, one may note the same phenomenon today, with many Americans loath to give up their huge gas-guzzling automobiles on which their way of life depends, in the same way that Britons earlier refused to give up their "pokeable, companionable fire".

Ashby and Anderson's second conclusion was that it is difficult to pass a law unless there are effective means of enforcing it. In the case of smoke control, and I would say of environmental protection generally, one is dealing with many subjective factors in trying to rid oneself of nuisances which cannot easily be measured or even defined. There has to be the social will to overcome these difficulties. Smoke abatement is possible not so much because one can nowadays define clean air, but because it is "becoming one of the expectations of industrial society. By general consent it is an unsocial act to emit smoke". And this leads to their third conclusion, which was that the measures to be taken have to be politically practicable. "Only a government can protect air and in a pluralistic democracy no government will act without a substantial backing of public opinion. The cost of cleaner air was not only a money cost; it required also a certain surrender of private liberty for the public good: the liberty to pollute. Social values and traditional habits had to be changed before these costs would be paid. Credit for generating this change goes to the tiny minority of enthusiasts ..... whose persistence and vision have surmounted indifference, hostility and the pressure of vested interests". And, of course, they paid tribute

to the National Society for Clean Air and its forebears.

The role of public debate, in other words, was crucial in bringing about abatement, as it is proving again today in many other aspects of environmental protection. I will cite just two examples: the public protest against noise near airports, which has led to a radical redesign of aircraft engines and their introduction before it might otherwise have been economically desirable; and the public concern about the long-term disposal of nuclear waste which in the last few years has forced the nuclear industry to pay far more attention to the nuclear fuel cycle in the light of waste management. In both cases the science was largely known, and much of the technology could be foreseen. It was the will that was missing, and this was supplied by public opinion led by the persistent few.

Governments are more responsive to public opinion nowadays, so the time scale for social and legislative change may be shorter than it was with smoke abatement. But the lesson appears to be the same, that informed public opinion is needed if technology is to be environmentally acceptable.

Before I pass to the proper subject of my address I would like to pay tribute to those like Mr. Tony Benn and Mr. Peter Shore who are genuinely trying to discuss in public the policy issues for which they are responsible. There are many in industry and in the Government who still think that decisions are best taken by experts behind closed doors. From the point of view of reaching a quick decision they may be right. But that usually means relying upon vested interests, or their supporters in Government to take decisions; and it is by no means evident that the result is one that accords with the wishes of others, such as the consumer, or those who care for good management of the environment, or the public at large.

In the end, major technological choices are political choices to be made by politicians. It should be something to rejoice in that ministers are gradually demanding to have exposed all relevant aspects of a problem before they take their decisions. The only way they can be sure that all aspects have been exposed is to encourage public debate. This should not be seen as delaying tactics, but as an attempt to set, and then to reach the most desirable objectives with as much public concensus as possible. It is part of our developing democratic process. And it is in part a consequence of the educational system that an ever more educated public wishes to be consulted about decisions taken on its behalf.

I see the main function of the Commission on Energy and the Environment to be to contribute to the background against which informed public debate can take place.

Let me first of all discuss energy, and in doing so I shall take as my starting point the Government's Green paper on Energy Policy published in February. Energy supply and demand forecasts are very difficult, and have been notoriously unreliable in the past - one of the reasons we have an excess capacity for electricity production at the present time, combined with an underdevelopment of our coal resources. However, the oil crisis of 1973 has focussed attention sharply on the whole range of energy problems, with the result that prediction is becoming a more sophisticated and, one hopes, a more reliable business. One of the most noticeable consequences has been the sharply reduced rate of growth now foreseen for energy demand, which, combined with a recognition that conservation of resources can make an important contribution, has led to much smaller predicted growth rates for energy supply than was the case only a few years ago. Although not without its critics, the Green Paper represents the latest stage of Government thinking on energy supply until the end of the century. Let me therefore try to summarise it.

First, the world background. It seems certain that oil, the dominant fuel of most industrialised nations, will become increasingly scarce and expensive during the rest of the century, and beyond. By the year 2000 it will almost certainly have ceased to be the world's marginal energy source as it is increasingly set aside for other purposes such as transport and petrochemical feedstock. Its place on that time scale can only be taken by coal and by nuclear electricity. Although coal resources as such are very considerable, it is doubtful whether they can be mined at such a rate as to make a substantial contribution from nuclear power unnecessary. Indeed, it is foreseen that there may be a requirement for nuclear power which, on present uranium supply prospects, cannot be satisfied beyond the year 2000 with the present kinds of thermal nuclear reactor which burn less than 1% of the uranium fuel. The alternative energy sources of which one hears so much - wind and wave power, solar power and fusion - are unlikely to make a significant contribution before 2000. Unless energy conservation is accepted to such an extent that it radically alters our life styles and economic prospects in the meantime, it is likely that fast breeder reactors will be needed from about 2000 onwards since their uranium utilisation is greater than that of thermal reactors by a factor of 50 or more. At least, with alternative sources undeveloped as they now are we cannot rely upon things being different then; supply policy, as distinct from research

and development, can only be based upon what has been reasonably established through proven technology.

So far as the UK is concerned, the most striking feature of the supply situation is the prospect of 10 to 15 years of net self-sufficiency in energy from about 1980. The UK has substantial reserves of oil and gas and very large reserves of coal. But when North Sea oil and gas begin to turn down during the 1990's the UK will face a return to imported oil which is then likely to be both scarce and expensive. Like other nations we therefore have to effect a transition to an economy in which energy conservation, coal, nuclear power, and perhaps some of the renewable sources, are seen to be more important than at present. The Green Paper underlines the danger of allowing a temporary abundance of supplies to obscure the seriousness of the longer term prospects, particularly remembering that the lead time to develop even the well understood energy sources is long. It takes, for example, about 10 years to develop a new colliery, and about as long to build a nuclear power station.

The Green Paper assumes that the main influence on energy demand is likely to continue to be the rate of economic growth. Two growth cases are considered. In the higher case, which envisages 3% average annual growth of Gross Domestic Product, total fuel demand is seen as rising from the equivalent of 340 million tons of coal in 1975 to 560 million tons in year 2000, or about 2% growth a year in fuel demand. In the lower case of 2% annual growth of GDP, primary fuel demand would reach 450 million tons, or about 1% growth in fuel demand.

It is here, I believe, that the Green Paper's assumptions require very careful analysis and criticism, because it is only in the detailed demand forecasts that one can take into account the full range of energy conservation measures, both domestic in terms of house insulation and central heating, and industrial in terms of matching the form of energy supplied to the industrial process and in adopting processes which are intentionally less demanding of energy. Demand forecasts such as those of Gerald Leach of the International Institute for Environmental Development, and of Cheshire and Surrey of the Science Policy Research Unit of the University of Sussex suggest that energy growth even lower than that considered as the low case of the Green Paper may be sufficient without affecting overall economic growth. And it is well known that different countries use different amounts of energy to achieve similar levels of economic growth and standards of living. Britain uses more energy on this basis than Sweden and France.

It is here too that one should discuss the desirable levels of electrification. Because only about 35% of the energy of the primary fuel is converted into electricity in a power station, it would often be less wasteful of primary fuel to use it directly rather than to convert the electricity back into heat again. Some people seem to assume without question that 100% electrification is desirable. But if one were to use electricity only for applications where it was unquestionably best, such as lighting, telecommunications and traction, provided one could use primary fuel efficiently elsewhere, one might get away with only 10% electrification. The range is so great that within it the requirement for massive development of nuclear electricity, for example, could be postponed for a long time. In this country there is no policy for electrification, except to allow it to be determined by consumer demand in response to the competing claims of the suppliers. It seems at least worthwhile to ask whether a more determinate policy would be beneficial.

The Green Paper identifies supply options which might yield a total of about 500 million tons of coal equivalent of indigenous energy in the year 2000 if all were successfully developed. This is sufficient for the case of low growth, but would have to be supplemented with imports in the high growth case. To take into account changing circumstances a flexible range of supply options is in any case necessary.

As far as indigenous coal is concerned it is estimated that total recoverable reserves are 45,000 million tons, sufficient to support the present rate of extraction for 300 years. The limitation, however, is not in the reserves but in the achievable rate of extraction. Production last year was only 120 million tons. To achieve a production of 170 million tons in the year 2000, annual investment of £400 million would be required to provide the 4 million tons of new capacity required each year.

The Green Paper argues the need to ensure that the capability exists rapidly to expand the supply of nuclear electricity from the late 1980's onwards if that course proves economically desirable and otherwise acceptable. Certainly, few would wish to throw away the nuclear option altogether. This requires a proven thermal reactor system such as the British AGR or the American PWR and an adequate nuclear manufacturing industry. The largest programme which it is now thought prudent to embark upon would amount to 30 nuclear stations in year 2000 (not including any contributions from a possible FBR), equivalent to nearly 90 million tons of coal. This is very much less than was contemplated by the nuclear industry only 5 years ago when the Royal Commission on Environmental

Pollution was taking its evidence.

Regarding oil, the Green Paper states that the Government should seek to ensure that there is neither too sharp a peak nor too rapid a rundown in production. They should also support further research and development into enhanced recovery from oil fields where an improvement of each percent could mean increased production worth £5 billion. Estimated total reserves of the British continental shelf are in the range of 3000 - 4500 million tons. Production during the 1980's is expected to lie in the range 100 - 150 million tons per annum, equivalent to 170 - 250 million tons of coal.

The Green Paper argues that the development of natural gas reserves should be managed with a view to maintaining supplies to the markets, including the petrochemical markets, which can make best use of the special qualities of gas. Techniques for developing substitute natural gas from coal have been developed but further research and development is needed to guarantee them. The level of ultimately recoverable reserves is uncertain but it is thought to be around 4000 million tons of coal equivalent. Production of gas was about 60 MTCE last year and is likely to increase somewhat in the future.

Energy conservation is now seen as an integral part of energy policy. The Government intends to bring all public sector buildings up to a reasonable standard of efficiency over the next 10 years, and to provide for a scheme of grants to allow householders to have basic insulation. The demand estimates allow for a reduction in total energy consumption by the end of the century of about 20% below what it might otherwise have been, but many argue that with a vigorous and sustained national programme still greater savings could be achieved.

So far as the renewable resources are concerned, all are at present in the research phase only. A substantial and sustained effort will be required if these are to move into development and demonstration. Research and development on wave power, solar energy, wind power, geothermal energy and tidal power at present amount to an expenditure in the UK of about £16 million over the next few years and is growing rapidly. But it is unlikely that annual energy supply in excess of 10 million tons of coal equivalent will be available before the end of the century. If nuclear power seems inevitable between now and then it is because the requisite work on alternatives was not begun 25 years ago. We shall have to work hard if some of these sources are to compete with nuclear energy 25 years from now.

There remains only controlled thermonuclear fusion whereby the light elements are combined as in the sun and the hydrogen bomb to release energy. The fuel for fusion is derived ultimately from sea water, the reserves of which are so large that if the process can be proved, it may be seen to be the ultimate energy source. The prospects at present seem good; but even the optimists would agree that no substantial contribution to supplies is likely within 50 years.

Incidentally, these novel sources of energy are not as new as we sometimes make out. In 1899 John Perry, Professor of Mechanics and Mathematics at the Central Tech, which was later to become Imperial College, published a book called "Steam Engine" in which he wrote: "For the last 20 years I have warned of the time when our stores of energy will be exhausted. By spending a few millions, nine-tenths of the energy in coal could be realised instead of one-tenth. When our store of coal is exhausted, the greater part of our civilisation will disapper. Then all places of high tide will become new centres of civilisation. Men will try to utilise stores of energy now thought to be insignificant - direct radiation from the sun, internal energy of the earth, wind power . ... There may be a new source of energy in a form unknown to engineers .... If coal becomes more expensive, Lord Kelvin's idea of a reversed heat engine (ie, a heat pump) will find favour". That was 79 years ago, bit it sounds modern enough!

The Green Paper concludes then that as we move into the next century the world's available oil will need to be increasingly reserved for uses for which other fuels cannot readily be substituted, particularly for transport and petrochemicals. To some extent coal may be able to fill the gap caused by the withdrawal of oil from crude heat production, but coal itself may be needed as a raw material for the production of synthetic natural gas, of transport fuels and perhaps of petrochemicals, so that the amount available for electricity generation may actually decline. Fusion power and the renewable resources cannot yet be relied upon, however attractive they may appear, until the development has been done, and this will take 20 years or more. The only things we can rely upon in 1978 to fill the gap in the year 2000 are coal and nuclear power; but by that time, if we work hard and devote sufficient resources to their development, other choices may be available. The real energy crisis is not now; it is in the first quarter of the next century. We must prepare for it and we must be flexible.

As Lord Nathan put it in the Report to which I referred earlier: "The present urgency to secure energy supplies must not lead to

a crash programme leaving a trail of disaster in its wake. A policy for energy must evolve with new technology. Accordingly it is not only wrong but futile to envisage that a policy for the next 20 or 30 years or even longer can be created now, a blueprint which marks out in detail the policy for years to come. Nonetheless, technology does not evolve with such rapidity that a policy cannot be determined within the framework of a long-term plan".

In particular, the strategy sketched out in the Green Paper has environmental implications which should be foreseen, just as we try to foresee the demand and supply options for energy, so that we may take them into account as we progressively determine our energy strategies.

Take coal, for instance. In order to raise annual output from 120 million tons to 170 million tons in the year 2000, the National Coal Board may need to open between 20 and 30 new deep and open-cast mines. Coal mining has been with us for a long time, and many of the detrimental impacts of the past are still to be seen in spite of great efforts to reduce them recently. Mining affects large areas of land, although a modern underground colliery will use a surface area of less than 100 acres, comparable to a medium sized factory employing the same number of workers (a few thousand). There are also transport facilities, usually rail, which increase the disturbance to surrounding areas. With modern technology it is possible to control land subsidence in newer mines so as to lower the undermined landscape uniformly. Back filling can reduce the level of subsidence but only with a substantial increase in cost, and often there may be insufficient waste material available. The disposal of spoil on unsightly and sometimes dangerous slagheaps has been abandoned. New developments are carefully controlled by level tipping and progressive landscaping, and in some cases waste can be piped out to sea in the form of a slurry.

Direct pollution from modern coal mining is largely limited to the water used for washing out spoil. This is kept in ponds where the spoil rapidly settles and as far as possible the water is re-cycled. The most important source of pollution is water seepage from derelict mines which contaminates rivers and water sources.

There are also socio-economic considerations. New mining operations affect patterns of employment in the surrounding area with implications for housing and transport. At present new mines tend to be located on the edge of developed coalfields so that the existing workforce may be able to commute from their homes. When

new areas are opened up, however, it will be necessary to integrate the new work force with the existing population. The fact that the modern miner is a skilled worker whose pick and shovel have given way to sophisticated machinery may help here, especially since agricultural workers do not seem to be tempted underground.

The safety of miners continues to give concern, and is often cited as an argument for nuclear power as an alternative. However, although the hazards of underground mining still remain, accidents caused by methane explosions and roof-falls are becoming less frequent thanks to mechanisation and adequate air-conditioning. Haulage systems now represent the greatest hazards. The incidence of pneumoconiosis, too, is declining as a result of massive reduction in put dust levels.

I will not give a similar catalogue of environmental factors affecting gas and oil. The main considerations are air pollution from petrochemical works and power stations, and the appalling hazards of oil pollution to sea and shore such as we saw in the Torrey Canyon episode and more recently in the Ekofisk blowout and the Amoco Cadiz disaster. Not only are beaches contaminated, but the effect on bird and marine life can be fatal. One should also take into account the pollution created by industry burning these fuels directly in manufacturing processes, and by motor vehicles, but I shall not do so today. It is fair to point out however, that the use of electricity by industry, although sometimes wasteful of primary fuels at least reduces the pollution produced at their works which are usually in closer proximity to human habitation than the power stations.

The production of electricity is the largest of the energy producing industries in the UK with assets in England and Wales of £6000 million and a turnover of £400 million a year. Although the land taken by power stations is not large in relation to other industrial plant, the enormous size of the structures make them a dominant feature in any landscape.

A modern fossil-fuelled power station producing 2000 MW of electricity requires about 300,000 tons of cooling water per hour, much more than we can find in British rivers except in tidal estuaries. Cooling towers, however, in which the water is very largely recycled, take only about 3% of the river water which would be required for direct cooling. One-third of the water is evaporated, the remaining two-thirds being returned highly oxygenated and purified, but more saline, leading to noticeable improvements in the river downstream. Moreover, not everyone would

regard a cluster of cooling towers as a visual disamenity; in the right landscape they can add a majestic splendour!

Much more serious, as the Society knows, is the air pollution from the products of combustion in the boiler furnaces. Grit arrestors are used to remove the dust which causes smoke, but the flue gases also contain sulphur dioxide of which not more than 90% can readily be removed, and then only with the use of expensive washing equipment which reduces the efficiency of power generation. To scrub out all the sulphur dioxide from all our fossil fuelled stations would increase primary fuel consumption by about 2% - about the amount of energy that might be saved if every house in the country used solar panels to produce its domestic hot water! Moreover, by cooling the flue gases scrubbing can cause more air pollution at ground level in atmospheric inversion conditions than it normally prevents, and it also creates a considerable water pollution problem.

In this country we have preferred to adopt very tall chimneys from which the flue gases are so greatly dissipated that only a very small concentration of sulphur dioxide will reach ground level nearby. Such chimneys add to the capital and energy costs of electricity generation. Growing concern, moreover, is nowadays being expressed about the effects of "acid rain", namely rain in which sulphur dioxides have been dissolved, falling particularly in regions deficient in calcium and with acid soils. It is known that sulphur compounds released high into the atmosphere can travel long distances across seas and national frontiers. It is thought that a quarter of the sulphur dioxide deposited in Norway arises from the United Kingdom, with perhaps a similar amount from West Germany. Although knowledge of the effect of sulphur dioxide on crop yields and fish is at present limited, and although mineral weathering, agricultural practices and fallen leaves can cause more acidification than does precipitation, increasing attention to the pollution transported from the high stacks of the power and other industries is bound to be required, and it may prove costly to remedy.

Power stations burning coal also have to dispose of fly ash to the extent of 15 million tons a year in England and Wales. Some is used to make breeze blocks, most is used for fill. One can even grow grass on it, on which sheep may safely graze.

There is also growing concern about the climatic results of the continual global increase in the emission to atmosphere of carbon dioxide, the inevitable result of burning fossil fuels. A recent

report by the US National Academy of Sciences has concluded that it may therefore be necessary to restrict the burning of these fuels within 20 or 30 years. Since the start of the industrial revolution the CO_2 content of the atmosphere has increased by about 12%. According to our present models of global climate, the next 40 years may see a rise of about 1^oC in mean temperature arising from world forecasts of fossil fuel consumption. However, there are many complications not yet fully understood which could increase or decrease the resulting environmental effects. Moreover, the increased CO_2 concentration may in part result from large scale deforestation seen in many parts of the world. What is certain is that we must do a lot more work on climatology and on macro-ecology during the next decade in case we have to make a gradual shift to non-fossil fuels in order to protect the global climate and prevent gradual melting of the polar ice caps during the next century. The time-scale for action, be it noted, is comparable with the introduction of new energy technologies: it is not so far off that we can afford to postpone serious investigation.

We have seen that it is necessary to suppose at the present time that there will be a rising contribution to our electricity supplies from nuclear power. The main features of the nuclear industry giving rise to public concern are the safety from radiation of those working in nuclear plants and in the surrounding areas, the possibility of a serious accident to a nuclear installation, the disposal of nuclear waste in such a way that it will not prove a threat to present or succeeding generations, and the fear that the growth of a nuclear industry throughout the world will lead to the proliferation of nuclear weapon capability amongst many countries. All these matters were reviewd in depth in the Sixth Report of the Royal Commission on Environmental Pollution which was published in September 1976. Most of them were reviewed again by Mr. Justice Parker in his Report on the Windscale Inquiry published earlier this year. I do not want to go into all these controversial issues again today, even though they represent the most publicly debated aspects of energy policy.

I have described a few of the issues that will face the Commission on Energy and the Environment. In announcing the new Commission, the Secretary of State for the Environment said: "The task of the new body will be to provide the Government with authoritative advice on the interaction of energy policies and the environment. The Commission will have a great diversity of interests. It will have to consider the environmental implications, nationally and globally, arising from the production and use in the United Kingdom of coal, oil, nuclear power, gas and electricity. It will

need to examine the environmental side of renewable energy sources. It will be concerned with pollution. It will also be concerned with planning (although not with specific planning cases), examining the interface between energy policies on land-use planning, and the implication of such policies for the natural world and the urban environment."

This statement draws special attention to planning, and I would like to end by discussing this aspect of our task. Energy policy deals with questions of supply and demand on a national, if not global scale. By contrast, local circumstances are usually the most important factors in planning. There are few absolute constraints on environmental and planning policy. To be sure, if it proved impossible safely to dispose of nuclear waste, or if it were shown that increasing levels of atmospheric CO_2 were harmful, these findings would place a limit on the exploitation of nuclear or of fossil fuels. Generally, however, the assessment of the environmental effects of energy production and use involves balancing a range of considerations that will differ from place to place. Only when energy policy is worked out in some detail, when sites and routes can be identified at least in principle, can the scale and quality of the environmental impact be assessed.

Even in individual cases planning controls are designed to be flexible. The broad objectives are to safeguard health, to conserve and improve as far as possible the physical surroundings that people value, and to meet the needs of housing, employment and recreation so as to provide an acceptable working and living environment. Of course, part of the job is to provide sufficient energy in the right form! But only those objectives which safeguard health can generate, where the evidence exists, fairly rigid controls. Even here the risks can usually be reduced at a cost, so that it becomes a matter of judgement how much it is prudent and practicable to spend in given circumstances. There are also inherent conflicts between them. Development and change conflict with conservation. Much of the practical work in planning is concerned with reconciling these conflicts and deciding on compromises which the flexibility of planning and environmental controls is designed to assist.

Applications for planning consent are thus considered singly, case by case, whether it is the Windscale plant or the Archway Road. There has to be an opportunity for factors affecting the choice of individual sites to be argued out against a detailed proposal. But it is perhaps for consideration whether in view of the sheer scale of development of new coal mines and power stations, and

perhaps in the future of some of the renewable sources of energy, whether more work should not be done of a conceptual kind at the strategic level.

An example of strategic planning made necessary by the pressures to develop North Sea oil is provided by the policy guidelines published by the Scottish Office. These set out preferred zones for conservation and for development along the Scottish coasts. Guidelines of this nature do not constitute a plan, nor do they prejudice the decisions of the planning authorities or the Secretary of State on individual cases. Case by case consideration will always be necessary; but it can be argued that the sheer unpredictability of sporadic local hearings could encourage an overall development that is logistically and environmentally unsatisfactory. There is also the danger that it will become increasingly difficult to win public cooperation and acceptance unless people can see how individual proposals fit into the total picture.

It is then in this total context of imperfectly predicted energy demand, uncertain contributions from the different sources of supply, local and global environmental consequences of different energy strategies, and the planning framework within which we all have to work, that the Commission on Energy and the Environment has decided that its first major study shall be concerned with the implications of coal production in the long term future, and of the use of coal including its conversion to other fuels and feedstocks. I am glad to say that the National Coal Board has agreed to participate fully in this study.

I will end as I began with a quotation from Lord Nathan's splendid report. After reviewing, as I have done, some of the environmental implications of energy policies he said: "They should be considered in the evolution of energy policy and not as an afterthought. If energy policy is determined without regard to them it will be confronted, as it has been, by a public outcry led by an environmental lobby. To choose the best policy and to implement it the Government, Parliament and the public must be informed of the options that are open and the consequences of adopting each." The Standing Commission on Energy and the Environment will do its best to let Lord Nathan have his way. By all appearances it will keep us damnably busy.

SESSION 2

TOWARDS A SATISFACTORY ENVIRONMENT
Dr. Erich Weber

TOWARDS A SATISFACTORY ENVIRONMENT
P. J. Wilde.

Prof. R.S. Scorer (Individual Member), opening the discussion, said that the two papers had displayed viewpoints typical of our era. We had, as a community, never said "we have gone far enough in this direction" or that we had already gone too far, but sought instead to overcome the difficulties and problems we had created in order that we could continue in the same direction.

This meant thinking out ways of enabling urban and industrial growth to continue. Planning had ceased to be seeking to achieve an ideal or desired state of affairs: it was instead a moronic procedure of finding out from the trends what would probably happen and seeking to facilitate those trends. Legislation, therefore, tended to permit what we can afford to permit both in damage by pollution and in expensive equipment to prevent it: it did not usually represent an attempt to turn into new directions.

Legislation was conceived on the basis of assumptions. For example it was widely assumed that a dose-response relationship actually existed, to be discovered. There could well be a response by a particular person to a particular dose of pollution, but all individuals and situations differed and it was impossible to protect everyone against all possible (but not necessarily actual) dangers or against their own foolishness. Bronchitics simply should not wander on to busy streets on foggy days. Again, in seeking air quality standards it was assumed that whatever monitoring might be appropriate for the legislation was actually feasible. Yet, even regardless of the cost, many people who made such assumptions seemed to have thought rather little about the meaning of the measurements that were actually practicable.

The rules invented for us, to make our society run healthily, had been designed on the assumption that it was good to reduce any dependence these rules might have upon human judgement. But then when the machinery or the bureaucracy did not run properly, it made ninnies of us. How long to wait before crossing a traffic light stuck at red was not a very difficult problem to answer on one's own responsibility, although the system was not

designed to help or encourage such people as are ready to take such responsibility. How much more specialist knowledge would people have to have, or presume to have, in order to ignore a measurement made according to the rules of the system?

To justify regulations we were inclined to invent principles and then stick to them as if we had found an immutable law of nature. But principles should, and did come after a long experience of many examples of their application. Thus, we knew killing was bad before a commandment not to kill was formulated, and we could all think of cases in which the commandment should be broken. We needed second principles also, to follow the first principles, and (who knows?) third and fourth ones too.

The so-called "The Polluter Pays" principle was a nonsense, and whatever procedure was chosen to control pollution was dutifully rationalised so as to pretend it arose out of the principle. If an industry were compelled to spend more on reducing pollution, we said that society was the polluter if we chose to subsidise the expenditure, and that the customers were the polluters if we chose to allow the costs to be added to prices. In reality we did not follow the principle but merely pursued arrangements which fitted in best as we saw it, without taxation and "planning" machinery, with the seriousness of the case, with the magnitude of the cost, and with the public mood which could vary (not in a logical but more in an emotional way) from indifference to outrage.

A great deal of the argument which is set off by the statement of principles was a nonsense too. Thus, whatever might be said, we DID have air quality standards in Britain, for we knew quite well what we did not like and what we were trying to get rid of. And elsewhere they DID seek to use the best practicable means available. None of us really believed that the siting of industries should be based on abstract judgments taking no account of local conditions - whether they be topography, urban development, climate, or social needs.

The rationalising and shadow boxing over nonsenses stopped us looking at the fundamental cause of such malaise as we have. Tony Crosland used to say that the real pollution is the excessive numbers of people. All our problems arose from too much (in quantity) of what we do, or in special cases such as particularly pernicious chemicals, from too much hurry; and the hurry was of course prompted by too rapid growth of populations, of their affluence, and of the problems that affluence posed.

Thus pollution was essentially a problem of growth, and before long we should need to stop it, not in qualitative terms, but in terms of tonnage of turnover. What we need was not so much a Ministry for the Quality of Life as a Ministry for the Quantity of (human) Life.

Pollution problems were absolutely endemic in a growth motivated society such as the E.E.C. Our planning was designed to fit as much of it in as we could. A system which sought, as a primary and professed aim, to facilitate growth would guide us into a situation with no options left. People needed to be reminded that if everything were really maximised we would be absolutely stuck with what we created, and we would have no option to choose anything which cost more, used more resources, or was less efficient, even if it were highly desirable for other reasons.

Professor Scorer emphasised that he was not proposing here any solution to the population problem. He did not think a practicable one would be found until the central role of excessive population in creating our predicament was widely understood. Perhaps our first job was to inculcate that understanding in people's minds, beginning in primary school.

Mr. S. E. Cohen (City of London) referred to paragraphs 26 and 28 in Mr. Wilde's paper, which mentioned the City of London as being the only local authority whose whole area of control of the sulphur content of fuel oil is being enforced. The City of London had won a 3 day fight in the Commons Committee to obtain these powers as the result of Mr. Cohen's efforts ably supported by expert witnesses. As a result, the City had attained, up to December 1977, a 50% reduction in sulphur deposits in recent years and the trend would continue. The Act had paved the way for the Government to include a similar clause in the Control of Pollution Act 3 years later. He said that a new factor affecting summer statistics is the increasing use of air-conditioning installations. He was surprised and disappointed, as it cost rate payers nothing, that other local authorities, particularly those where it is most needed, such as large conurbations, had apparently not applied to the Secretary of State to exercise similar powers under Section 76 of that Act. He thought that the benefits of such actions are considerable for, combined with the smokeless zone Act of 1954, there had been savings in the City in reduced erosion of property, amounting at 1978 to an estimated £4 million a year, and there were fewer admissions to hospital of respiratory and cardiac diseases.

However, the City does, he pointed out, suffer from pollution

drift from Westminster (including hot air !) and other surrounding boroughs and, although there are limitations of availability of appropriate oil, fortunately boosted by North Sea resources, he urged Westminster and other suitable authorities nationwide to take immediate action.

Mr. A. Verdin (Analysis Automation Ltd.) said that he would modify his intended remarks after listening to Professor Scorer.

As a vendor of air pollution monitoring equipment, he was not conscious of having had any effect on British pollution control strategy. He thought it absolute nonsense to say that air pollution monitor manufacturers (very small fry even in the air pollution control market) have made the installations of monitoring stations necessary. Their instruments had been developed to meet the monitoring needs of U.S. legislation.

Mr. Wilde had told the Conference that we will need to use guidelines or standards in Britain. Mr. Verdin felt it had been obvious for many years that standards are a necessary element in any reasonable approach to pollution control and he was sorry to see Britain lag rather than lead when the path is clear. He said that standards required real-time monitoring and, here again Britain was lagging behind - not only behind France and Germany, but also behind Australia, Spain, Portugal and many others in the installation of comprehensive monitoring stations using current techniques.

A side effect of this, on which he had previously commented at Clean Air Conferences, was that most monitoring instruments were being imported and Britain had lost an export market well suited to its skills. It was not a problem for his company as they also imported advanced analysers. It was a lost opportunity. Four years ago, Analysis Automation had started on the development of two new monitoring methods, but with no market incentive in Britain efforts had been diverted into more immediate fields. American made instruments using both of these methods had been shown at the American Air Pollution Control Association meeting in June 1978.

While agreeing with Professor Scorer that many environmental problems are caused by overpopulation, he completely disagreed that air quality could not be controlled. Increased production with reduced emissions is, he said, possible. He gave the example of the control by chemical companies of workplace atmospheres of vinyl chloride to levels below those thought possible before legislation and the urgency of the problem forced it.

He thought that monitoring had played a very important part in that instance.

He felt that the concept of standards had been completely misunderstood by many of the speakers. The promulgators of the US standards, on which all others have been based, had made it clear that those standards were not absolute but were based upon the best available evidence then. It had also been made clear that they were not to be used as acceptable levels to which cleaner atmospheres could be degraded. Rigorous linking of air quality to emissions was, he thought, difficult, but that concept was the only one tenable to set desired (practical could come later) emission standards. Monitoring of both as a result of that legislation had led to much better data for setting future standards, which could have been obtained in no other way.

Mr. B. Kidd (Newtownabbey B.C.), referred to the situation in Northern Ireland, where, he said, extreme poverty existed, which meant that when Clean Air Legislation was being introduced, it could lead to financial hardship for many homes. He said that gas and electricity for domestic consumers was approximately three times the price as on the U.K. main land, and smokeless coal was £1.60 per bag more expensive. He wondered whether any other area of the E.E.C. suffered the same disadvantage when introducing smokeless zones, and he wanted to know whether any plan existed to counter the situation, or whether anyone could recommend a solution.

Cllr. J. J. Rooney (Newtownabbey B.C.) said that he had been very interested in what Dr. Weber and Mr. Wilde had had to say about the control of pollution in the air. He thought that it was possible that governments, and for that matter Local Authorities, could to some extent control pollution by legislation. He mentioned Germany as a typical example, where in some areas, only low sulphur, high cost fuel oils were allowed to be burnt, with an embargo, he thought, on oil containing sulphur in excess of 0.5%. He felt that such restrictions in the U.K., where fuel oil containing over 3.0% sulphur was being burnt, would be most uneconomic particularly at a time of high fuel costs. He thought it applied particularly relevant to Northern Ireland, where as Councillor Kidd had said, energy costs were indeed the highest in the United Kingdom.

During recent times, he said, a new technology had been developed in the form of fuel additives, which were being used in England,

but more particularly in countries such as Belgium. The additive, mainly magnesium oxide, is injected into the boiler gas stream, principally to counteract SO_2 emissions and acid smuts, which can occur in areas around major oil burning plants such as Power Stations.

The installation of such fuel additive plants would, he had no doubt, put a heavy financial strain on Power Companies, such as the Northern Ireland Electricity Service and indeed for that matter the C.E.G.B. This expense unfortunately would of course have to be passed on to the consumer.

As Britain could not afford the luxury of burning low sulphur, high cost fuel oil, he thought that perhaps there was another way around the problem. There is (1978) a considerable revenue intake from the sale of North Sea low sulphur oil to the continent of Europe. He suggested that a slight increase in price in the form of an anti-pollution tax should be levied on this high premium fuel oil. The tax could be creamed off to help finance and indeed maintain such fuel additive plants, which would require to be installed in the United Kingdom.

He posed two questions to Dr. Weber and Mr. Wilde:

1) Whether fuel additives are successful in reducing air pollution
2) Were the answer to be 'yes', how did they feel about grant aiding the installation and maintenance of such plants from Government funds.

Mr. T. Townsend (Midlands Joint Advisory Council for Clean Air and Noise Control), said that Dr. Weber had stated in his paper that "Action taken at local authority level is above all aimed at reducing emissions from smaller facilities, central heating and domestic firing installations". His comment was that it appeared to be a misconception held not only by other E.E.C. countries but also by Central Government. Whilst he did not argue that it could be the case in the majority of the rural areas, in the large conurbations, particularly from his own involvement in the West Midlands area, the reverse was, he said, true and Local Authorities were responsible for emissions from major industries the ferrous foundry and hot dip galvanising industries being typical examples.

Dr. A. Parker (Individual Member & Past President) mentioned that one contributor to a discussion had said that the control of air pollution was more stringent in the United States of America than in any other country. He said this was true only for Los Angeles,

California, where the local authority had taken vigorous steps to reduce all kinds of pollution to the lowest practicable minimum. In the area in which people lived, factories that emited significant amounts of sulphur compounds were not allowed; they had to build some distance away.

In addition, he said, Los Angeles employed staff who travelled by cars in all parts of the area and followed vehicles emitting any sign of fume. They took photographs of the fume with special cameras and then travelled to get in front of the offending vehicle and stop its movement. They then showed the photograph to the driver of the vehicle and took his name, the number of the vehicle and the address of his employers, who might be subject to a fine.

There was not the same stringency in other states in the U.S.A. Each state in the U.S.A. was largely independant and made most of its own laws, including those in relation to the control of air pollution, which might be different in different states.

Mr. P. Draper (Individual Member) said the main difference in approach to air pollution control between Britain and the rest of the E.E.C. was the use of 'best practicable means' and the laying down of 'air quality standards' respectively. He did not see how the 'air quality standards' could apply to all the variations in local conditions. For instance, in order to achieve the same a.q.s. in industrial and rural sites, quite different means of emission control would be required. Whereas if the b.p.m. were adopted at all sites, a cleaner air overall would result, and similar emitters could be treated in the same manner wherever located.

Mr. Draper considered it better to adopt the best practicable means in all cases rather than to lay down and attempt to comply with air quality standards whether practicable or not. The British flexibility of approach, while observing 'guide lines' seemed to have much to recommend it.

Mr. G.W. Maxted (Kingston upon Hull D.C.) directed his remarks to Mr. Wilde's paper. He wished to make a plea for:

(1) Standardisation of sampling methods
(2) Standardisation of equipment, instrumentation etc.
(3) Standardisation of analytical techniques
(4) Standardisation of reporting of results.

In addition he wanted to see a right of inter-country powers of inspection brought into being.

Mr. H.I. Fuller (Esso Petroleum Co. Ltd.), contrasted Dr. Weber's fixed emission standards with Mr. Wilde's air quality objectives or targets. Dr. Weber had stressed that he wanted to see uniform emission standards which would have to be obeyed no matter what the background was. If these limits were based on the latest state of emission abatement technology, as Dr. Weber had indicated, Mr. Fuller was concerned that these would reflect the attitudes of a particular period and that they would be difficult to modify in the light of better information. For instance, views about the health effects of sulphur dioxide had changed with the years. Indeed, some people were now stressing the great importance of Suspended Particulate Matter which, as "smoke", the UK had long believed should be controlled, but there was continuing debate as to how SPM should properly be measured in relation to health. Until this was agreed, it would be difficult enough to set air quality objectives - certainly not fixed emission standards.

Mr. A.J. Clarke, said he believed there were a number of points in the two papers that warranted further debate. He thought there would be strong opposition in the UK to some of the views expressed in Dr. Weber's paper; for instance the suggestion that uniform measures of emission control were desirable throughout a territory. Long experience in the UK had demonstrated the highly localised nature of most air pollution problems and that control measures should be tailored to suit the individual circumstances. Mr. Clarke also thought debatable the idea that emission controls should be implemented to the limit of technical feasibility irrespective of demonstrable need or whether the costs were justified by the benefits obtained. These were merely two of the points that illustrated the divergence of philosphy between UK and the rest of Europe and he encouraged further discussion of the paper that had been presented.

Mr. T.H. Iddison (Environmental Health Officer's Association) agreed with Dr. Weber that all reasonably practicable steps should be taken to minimise increases in pollution in areas hitherto relatively pollution free. Whilst he was in favour of the best practicable means strategy, together with air quality guidlines, he would be strongly opposed to different emission standards for different parts of the country as appeared to be suggested by Mr. Draper. In his view it would be quite wrong to permit an industry to be established in a remote pollution free area, where it would be permitted to meet less stringent emission standards until such time as pollution levels demanded a higher standard of arrestment. There might conceivably be areas with such a high concentration of polluting industries that even more stringent emission standards would have to be met.

Mr. P. J. Wilde, replying to discussion, turned first to remarks made by Professor Scorer. He said that in the world as it existed today, administrators and legislators had to deal with limited horizons as best they could. He felt that Professor Scorer's contention that there might be 'too many' people, might or might not be true, but he said that the world's population was a given fact with which everyone had to cope.

He said that the 'polluter pays' principle did made sense. Either the user of the good or the community at large would have to pay. It made a material difference, and the former was a suitable basis for policy. He thought that Professor Scorer had been too harsh on the problems of establishing a dose effect relationship. He said this could be done to a certain extent with sufficient general reliability, to be the basis of action in some cases. He remarked that economists' ways of thinking had a place wherever resources were limited and decisions had to be taken about comparatives. That, he said, included environmental protection.

Turning to the question put by Mr. Kidd, Mr. Wilde said that he was not an authority on Northern Ireland. He did however appreciate that the high cost of smokeless fuel could be a problem there. Turning to Mr. Rooney's question, Mr. Wilde said that fuel additives did not, to his knowledge, reduce the amount of sulphur emitted. To Mr. Townsend, he said that he appreciated the significance of the role of the Environmental Health Officers. They were a key part of the control system. He thought that it was important that Environmental Health Officers and the Alkali and Clean Air Inspectorate should co-operate in control matters.

Commenting on Mr. Draper's remarks he said that there was a need for air quality guidelines and emission standards (BPM) to be used together in harmony. He said that emission controls were the primary element in pollution control. Finally, replying to the remarks made by Mr. Maxted he said that he sympathised with views he had expressed. Mr. Wilde said that ISO work was going on, but it was a very slow process.

Mr. Wilde said that pollution control was now an established part of European social policy, and that German and U.K. practice, for example, was not really as far apart as legislation might lead one to suppose. He thought that adequate inspection and testing lay at the heart of any control system. He emphasised that air quality considerations of some sort were clearly going to play an increasing part in U.K. thinking; but that he thought there was a need for controls to be practicable and cost - effective.

Dr. Erich Weber, replying to the discussion, said that, particularly as far as he was concerned, the discussion had been very interesting. For example, he said, the objection raised by Mr. Draper, that the introduction of air quality standards might result in a diminution of valuable flexibility, was right in theory but wrong in practice. Dr. Weber explained that air quality standards did not give the right to increase air pollution up to that level. On the contrary, air quality standards irrevocably made it impossible to allow any further increase of air pollution in areas where the concentration of pollutants already exceeded the air quality standards. In such areas the competent authorities had the duty to initiate measures for reducing pollution. A restriction of flexibility was caused by the establishment of air quality standards only at those places where a high level of pollution had already been reached. There, however, that was urgently necessary and desirable.

He agreed with Professor Scorer that the over-proportionate population growth, apart from industrialization, quite naturally, was the main cause of increasing air pollution and would perhaps continue to be so to a yet greater extent in the future. In addition to a control of the increase of the population, it appeared to him to be necessary first of all to bring about a change in energy consumption patterns. We ought to try to use forms of energy which caused considerably less or no pollution at all, such as solar energy, for example.

Mr. Fuller had expressed the opinion that uniform emission standards resulted in a fixation on the state of the art in a given period of time and that they rather impeded the development of advanced technologies. That objection was partly correct Dr. Weber thought, and there were examples for that. Up to that time, for instance, it had been possible only in a few countries to introduce in practice the technology of flue gas desulphurization, although it had only been developed and tested for practical application. It was the responsibility of the competent authorities to review the emission standards at regular intervals and adjust them to the latest developments of technology.

Mr. Rooney had drawn attention to the fact that the permissible sulphur content in fuel oil was positively lower in Germany than it was in the United Kingdom. At the time of speaking, the permissible sulphur content for gas oil in Germany amounted to 0.3 per cent. In new installations using heavy fuel oil the sulphur content was limited to a maximum of 1 per cent.

In other contributions to the discussion, reference had been made to the problems and costs of monitoring systems. It seemed to Dr. Weber that the costs were low as compared, for example, with the building costs of a larger power station. It might perhaps cost 0.5 or 1 billion pounds to build a large power station, while the necessary environmental monitoring system cost 0.5 million pounds at the most, less than 0.05 per cent of the building costs in most cases. He thought that this was not too expensive if it offered a possibility for the continuous monitoring of emissions and air quality standards and thus for ensuring the protection of neighbours and the environment.

THE TASK OF THE LOCAL AUTHORITY, MONITORING, MEASUREMENT, COLLECTION AND DISSEMINATION OF INFORMATION
Mr. L.E. Robson, Environmental Health Department, City of Bristol

THE ROLE OF HM ALKALI AND CLEAN AIR INSPECTORATE
Mr. S.J. Hart, formerly District Alkali Inspector, North West

THE TASKS OF INDUSTRY - MONITORING, MEASUREMENT, RESEARCH
Mr. H.I. Fuller, Esso Petroleum Co. Ltd.

Mr. D.H. Evans (City of Coventry), opening the discussion, felt it was very encouraging to see the three arms of pollution control sitting on the platform - local government authority and central government authority, and industry itself. But, he said, there was one person missing and that was a member of the public. Because of course the whole business about pollution, discussion at the Conference had revealed, was that it is about the people who are receiving it. As Professor Scorer had said, it might be a very cosy Conference, but Mr. Evans was certain that it would not have been quite as cosy if there had been some members of the public present, such as local authorities had to deal with at certain times. He thought that the 5th Report of the Royal Commission on Environmental Pollution had noted that, as had the 1974 Control of Pollution Act. What had been suggested was that Consultative Committees should be set up and in fact the Act had made it mandatory that wherever Notices are served in order to monitor emissions then a Consultative Committee had to be established; he had been rather surprised to see in Mr. Robson's paper no mention of such a Consultative Committee being set up in the Avon district, and he wondered whether in fact there was one, and if there was, what effects it had had. He had to admit that in Coventry there really was not a lot of choice, because the solicitor to his Committee was of the opinion that in the absence of a Consultative Committee any prosecution involving measurement within the factory could be stated to be ultra vires and the case might fail. That was one legal opinion, and he was sure that knowing legal opinions there was another legal opinion with exactly the opposite view - point, but it had not yet been overthrown and the DoE in fact had agreed that there was a mandatory requirement there, but that the Courts had to be the final arbiter of whether one is acting in an ultra vires situation or not. He said it was quite easy to form

such a Committee - it has been particularly easy in Coventry because (as people might be tired of hearing) the local authority had set up a Pollution Prevention Panel with industry; and all that they had asked industry to do was to select five members. Coventry selected five elected representatives and then they had asked for five good men and true from the community who knew about pollution. These had come from the University and the Polytechnic and included a Chairman of a Ratepayers' Association.

But he thought it should be remembered that pollution control is not a private exercise amongst experts - it is the response to the public need. He had regarded Mr. Robson's paper with extreme humility - he thought a superb exposition of an enormous task, but he had been particularly impressed by his analysis of the costs. Phrases like "it costs just a matter of peanuts", were often used but in the Bristol area it obviously did not cost even one bag of peanuts per person per annum. Mr. Evans was rather astonished that all the work was being carried out with one and one third man years, and he thought that they really had to go at a tremendous pace to get through all of the work described.

In Coventry, the Environmental Health Department had been constrained by man power resources and by money, and they had a different and more pragmatic approach. Their policy was first to visit the factories (and through the Prevention Panel they could do this) find out what the processes were, consult with the engineers on what parts of these processes might be dangerous and then monitor more intensely those factories which were most likely to produce a contravention or a decline in the environment.

Referring to Mr. Hart's "lucid and calm" paper Mr. Evans reflected that Alkali and Clean Air Inspectors always seemed to be calm, but he warmly welcomed the increased liaison with local authorities and particularly the statement that it was the duty of ACAIs to consult with local environmental health officers twice per annum. He said that he always envied an alkali works inspector his calmness. He thought that Mr. Hart looked hale and hearty after having retired from work. When he himself had been appointed to his job in Coventry he had been in two minds about whether to take it. Two of his predecessors had died from stress diseases in their fifties, and the third had gone off hurt only three years before at the age of 56. So he felt that Mr. Hart's good health was due to lack of democratic hustling. Mr. Evans said that he himself was battered by Councillors, harassed by local associations and tenants, and had ratepayers to answer to, along with community groups, action groups, all encouraged by environmental groups - they were all growing more knowledgeable every day, with

the television programmes and all the other information they could get - they all seemed to know more about environmental matters than he did himself, certainly on the finer points of the law. Worse than that, they were continually reminding him that his compatriot, Pugh the Ombudsman, was always around to see that Evans the Health was being kept up to scratch. So he went home to toss and turn on the pillow wondering when he would be reported to the Ombudsman for something or other. At that point in time, although many delegates had thought that Professor Scorer's solution to pollution had been rather extreme (that we should reduce the population suffering it) he did see a lot of merit in it, and he could think of one or two in his locality that would not be missed!

He asked Mr. Hart first whether he was satisfied that there were enough ACAIs at that time - he remarked that as he was now retired from the job, he could speak frankly. He had said that they were increasing in numbers, and that they were going to increase further, but did Mr. Hart think there were enough. He had noticed that with the increase in the number of ACAIs there had been an increase in the number of infractions found. He did not know whether industry was getting worse, or whether the Inspectors were making more intensive inspections of registered works. Would they, he wondered, find even more infractions if there were more Inspectors. If they were to have more complaints, would their resources increase? Mr. Hart had said that they were open to complaints. Mr. Evans' own department had an emergency number, available at any time of the day and night. He asked whether there were enough ACAIs to have a night-shift and whether they had an answering machine for complaints which came in during the later hours of the night, or the small wee hours of the morning.

To Mr. Fuller he could only extend his commiseration. But Mr. Evans thought it might cheer him up to know that the whole of statutory law existed to prevent the whole of industry being shut up. He said that the common law is a very fearsome instrument and if it was available to everybody, he shuddered to think what could happen. After all interference with the comfort of occupation of land is a fearsome standard indeed. He pointed out that only the extremely unwieldy nature of the common law stopped its wholesale use. He also stressed that the 'best practicable means' defence existed because of the statutory provisions of law. He explained that a local authority has no choice of action whatsoever. It could not say - we have a complaint and we now agree to discuss the matter for two or three months - it has got a mandatory duty to serve a Notice if it is satisfied of the existence of a nuisance. From then on, it could start its discussion with industry

because the only part of the law that is not mandatory is the time given in the Notice to remedy the nuisance. Parliament itself had been a little wary, as the citizens are, about the cosy idea that all sections could work comfortably together. Parliament had made the provision mandatory because it had been perhaps a little suspicious that without the mandatory nuisance clauses somebody might sit by and do nothing.

Mr. Evans said, however, that he had every confidence in industry. Every problem that they had received, the solution to which had produced them a monetary reward, they had been able to solve in very quick time indeed! With the increase of the price of fuel, all cars could do a sight more miles to the gallon than they were formerly able to do. He suggested that perhaps industry is badly adjusted to the profit motive. If industry could only sell environmental standards, Mr. Evans thought they might all be working with great vigour to achieve a profit in those lines as well!

But fundamentally he considered total consultation to be the essential requirement. The lesson was that people had to be consulted. They had to be told, and when they were told, they usually took a much more reasonable line of action. There is one thing, said Mr. Evans, that infuriates the British - the idea that somebody else knows more than they do what is good for them and that they should all sit down and be quiet until Big Daddy does something about it.

Mr. J. Evans (Rhymney Valley District Council), wanted first to congratulate Mr. Robson on his excellent paper presented for the consideration of conference. He felt that Mr. Robson had produced a very detailed framework which all local authorities would do well to follow, suitably adapted to meet their own requirements.

It was, in his opinion, a matter for great concern that the way in which pollution control is operated by local authorities depends on the initiative of the Officers and elected members of those authorities.

Bristol of course, has extensive and complex industrial conurbations and obviously that fact, he suspected, had partly led to the evolution of their comprehensive pollution monitoring system. Many authorities had made, and were still making, efforts in the field of pollution monitoring. However, he felt that many of those efforts were not being directly linked to sources of emissions; he thought that without adequate initial research,

as outlined in Mr. Robson's paper, money would be wasted on monitoring programmes. He thought it was obviously important to achieve optimum cost benefit from any efforts that were being made. He wondered how it would be possible to achieve some uniformity in adequate pollution control and monitoring. Mr. Evans took the opportunity to ask elected members attending the conference to take a close look at the efforts which their Officers could make in such work with their present staffing situations, and also for Officers themselves to assess their present efforts in the area. He was also interested to learn the opinions of the speakers regarding increased and specific statutory requirements for pollution control work, bearing in mind the differing circumstances of various local authorities.

Mr. R.A. Carson (Southwark B.C.), was concerned that "gum-boot" philosophy was still prevalent when the question of monitoring pollution was being considered. He said that many local authorities use deposit gauges, simple smoke and sulphur dioxide samplers and even lead candles to determine levels of pollution. The monitors only give a crude indication of pollution levels and in the field of accurate measurement, they are neolithic tools.

Unfortunately, people might tend to regard statistics produced by crude monitors as accurate assessments to reassure the public and elected members. He said that Officers had to resist that tendency, and should advise their Councils that although tbeir Officers might have the technical expertise, accurate monitoring requires investment in staff resources and sophisticated equipment. The Officers' duty to the public is, he said, also important since the public trust the Officers, and are reassured by any statement made about pollution levels.

He pointed out that, during a period of high unemployment, planning development applications could be rejected on pollution statistics provided by crude monitors. What he felt was more important was that Officers might condition development, setting limits on pollution which could not be monitored accurately. The public could be reassured by the limitations without realising that the staff resources or sophisticated equipment to monitor emissions accurately, or enforce vital controls, might not exist.

In his experience, he had found HM Factory Inspector and the Alkali Inspector to be very competent and capable individuals in the field of pollution control. He said that their ability is above reproach but that the public were ignorant of their limited man-power resources. It was ridiculous to have the country served

by Alkali Inspectors in only 15 districts and even the Factory Inspector may only be able to visit certain works once every two or three years. Normally, the general public were not aware of these facts.

Regrettably, he himself had been thirty years old before he had realised that the Alkali Inspector was not an "answering machine" on the other end of a telephone.

Professor R.S. Scorer (London Borough of Merton), came across the professional complainers and the tendency was to write them off too readily. They represented a very important part of the public mood. Complaints very often arose simply because people did not know how things worked or what was going on. In our increasingly complex society it was becoming impossible for ordinary people to know "how it works". He said that we needed to realise, however, that not to know how it works did not mean that we could not take control: for example we all used our digestive system without understanding it, but in that case we had several million years of evolution and well developed instincts to guide us. When new things were thought up and introduced into society people needed to have time to develop an instinctive behaviour towards them, and rapid change in our institutions, whether of local or central government, shopping patterns, or health habits, tended to undermine people's confidence. If we knew from long experience what our institutional structure was and how to use it we could develop the confidence that we could control it, just as we control our digestions. As the management of society became more complex not only did fewer people know in detail how it worked, but fewer knew how to work it, and we got the feeling that we were being managed like a lot of kids, by the professional civil servants. An important aspect of this was that information, plans and policies must be shared with the people, primarily through their elected representatives, because that way people would learn to work the system.

Professor Scorer thought that one aspect of our life was very perplexing - unemployment. We were continually told to work harder when we knew that there were lots of people whom the system did not give work to and whom it was trying to create work for! Unemployment was an inevitable outcome of today's scale of population growth alongside industrialisation. It impinged on clean air problems very much because it became the source of irresistable economic pressures, and we have no instincts which guide us towards an elimination of it.

Because we needed evolution towards a greater public consensus in the running of our affairs, and because better management could

only come with experience, we had to take risks, as Mr. Fuller had pointed out. Indeed society had taken a gigantic risk in going for industrialisation and population growth, and Professor Scorer said he was not in the least joking when he had said that too many people was the chief source of our predicaments.

We had got too used to the idea that for every problem there was a solution, for every predicament a scientific remedy. That was why people assumed he had implied a "solution" to the population problem when he had mentioned it. But we were very near the point where the population could not be supported, for some said that two thirds of the world is undernourished. Even if it were only a half, that was still more undernourished people than the total number at the beginning of the century. Unless we talked about it that aspect of our predicament was bound to get worse.

Mr. G.W. Maxted (Kingston Upon Hull C.C.), congratulated Mr. Robson upon his paper and his Authority for providing the resources to establish an environmental monitoring system. He said that other Authorities had set up similar organisations and he believed that they would form the blueprint for environmental monitoring by all large authorities in due course.

Having said that, he suggested that there was still a significant lack of knowledge in interpretation and application of results.

He referred specifically to the lack of toxicological information. The Medical disciplines could explain what the probable effects of gross pollution levels might be but he wondered how much was known about the insidious lower levels. He asked at what level could a pollutant be called dangerous, and what level ought not be exceeded, allowing for varying human resistances, metabolisms, the sick, the young, the aged etc. Taking lead as an example, he said that it was necessary to know how much is ingested, how much breathed, and what is the natural content of lead in soil and vegetation. In parts of the world soil and some feeds are naturally radioactive. He felt that what was urgently required was a large scale survey to arrive at the natural norm for the various pollutants in soil, water, air, vegetation, animals and humans, then with that background knowledge it would be possible to embark on monitoring and control systems with confidence. He said that obviously that did not invalidate current investigations of gross local polluting sources but he felt that the general background knowledge he had referred to was urgently required in order to evaluate satisfactorily results obtained.

Mr. I. Holmes (High Peak B.C.), said he had listened to the papers with interest but he wished to express his concern regarding the dissemination of information to the public. It had been implied that the public had a right to be given more and more information and that such a situation was satisfactory. He wished to present the other side of the coin - the opposite view, which was unpopular and in some people's view even cynical. It was his experience that once detailed information regarding emissions and pollutants in the air had been released, the local authority lost control of that information. It could be used by mischevious people for their own egotistical or political purposes, and could be rehashed and re-quoted in a completely different form.

It was his experience that liaison committees which included members of the public, would not preserve the confidentiality of information given to them in confidence. It was not uncommon to read in the newspaper verbatim reports of confidential meetings with the public at these liaison meetings. He asked Mr. Robson how he had managed to control these meetings so effectively in Bristol.

He knew that Mr. Hart held strong views on the giving of information to the public. He asked whether it was not a fact that care had to be taken in the numerical scales chosen when supplying such information: tons per square mile, for example, could be emotive. Was it not a fact, he asked, that the sections in the Control of Pollution Act which dealt with the supply of information stated 'may' and not 'shall', clearly making it a discretionary power.

He said that his Authority is a member of both the Manchester and District Council for Clean Air and Noise Control and the Derbyshire Council for Clean Air and Noise Control, and explained that both bodies recommended extreme caution in the use of the statutory powers to obtain information from companies to be given to the public.

He also expressed interest in the very creditable work carried out by Mr. Robson and his officers in relation to environmental emergencies. Hardly a week went by without headlines in the press of "Gas-Cloud Affects Town". In the Peak District also, EHO's attended all environmental emergencies. They had investigated several deaths and many cases of people overcome by fumes. He asked whether Mr. Robson would like to see a change in legislation to make attendance at such incidents a statutory duty. It had been suggested, after he himself had given evidence in the Coroners Court that he cared more for the dead than the living.

He said that this might explain why he had spoken at the past two NSCA Conferences and given what had appeared to be very cynical addresses. He thought that Action Groups' view of the E.H.O. in the Peak District could best be illustrated by the story of the early Christian equipped only with a sword fighting a lion in the arena to entertain the Romans. He cuts the lion's head off whereupon he is removed of his sword and expected to fight the next lion unarmed. This he strangles to death. He is then buried up to his neck in the arena and a third lion released, the most ferocious of them all. Just as the lion pounces, he siezes it by the nose in his teeth, swings it round his head and pounds it in the ground until it is dead. The response from the public is a cry of "fight fair, Christian!"

Mr. C.G. Howell (Stroud D.C.), said that his District lay thirty miles from Bristol and he was aware that Bristol carried out a heavy programme of environmental monitoring, but until his very good friend E. Robson had written his excellent paper he had not perhaps realised the full significance of just how seriously his Department was implementing its statutory and moral obligations to the public. He suggested that that was because, like his own Environmental Health Department, Bristol had specialist teams or Divisions able to concentrate on that type of work.

His own attempt to contribute to the discussion was to enlarge on the work, and to put in a personal plug for the Avon, Gloucestershire and Somerset Environmental Monitoring Committee. Ewen Robson had been the prime mover in the formation of the Steering Committee and its first Chairman, and Mr. Howell paid tribute to his early work, culminating in the much acclaimed Report of the Committee on a Survey of Airborne Metals in 1977, details of which appear on pages 18 and 19 of Mr. Robson's paper.

He himself had the honour and privilege to follow Ewen as Chairman and, therefore, he was able to state that the surveys on Nitrates and P.C.B.'s mentioned on page 19, paragraph 6.14, had been completed on schedule. Both Surveys had been fully written up and appear in reports entitled :-

(a) Survey of Nitrates in Drinking Water, and -

(b) The Monitoring of P.C.B.'s in Selected Watercourses of Avon and Gloucestershire with three samples from Somerset 1977-1978, (copies of which would be available to any person interested. He said that if any delegates cared to contact either himself or Howard Nowell of Bath City, they would ensure that they received a copy).

Reference had also been made to lead in air in rifle ranges. In 1975 the American Department of Health Education and Welfare had published a paper concerning the lead exposure and design considerations for indoor firing ranges quoting dramatic figures for lead in air during operation of up to 35,000 μg per m^3. That figure compared to normal atmospheric levels of approximately 1 μg per m^3 in Avon, Gloucestershire and Somerset and a T.L.V. of 150 μg per cubic metre.

A preliminary study carried out by the Gloucestershire Environmental Health Officer at the Police Range in the County had indicated general levels of up to 3,600 μg per m^3. The Chief Constable had been so concerned that he was authorising the expenditure of some £20,000 to improve the extraction facilities at the range.

The desirability of a joint survey had been discussed by his Committee and a pilot scheme had been set up at Bristol, again with startling results. He said that the responsibility for these establishments lay with the Health and Safety Executive and they had written to them, drawing their attention to the situation. He regretted to state that they had received no response at all from the H.S.E. so he presumed they had had no objection to the Local Authorities carrying out such work! Was this typical, he wondered, or was he perhaps being unkind to H.S.E. They had then offered the services of the Joint Monitoring Committee to the Chief Constables of Gloucestershire, Avon and Somerset who had written back, supporting the project and offering full support from local Commanders in the seven police ranges in these Counties.

He said that he hoped to be able to commence monitoring from January 1st, 1979.

If results, as they had predicted, justified further action they would then turn their attention to private shooting clubs.

He said that the Committee provided a forum for the exchange of information, and as an instance, some of the subjects that had been discussed in 1978 included -

1. Solvents and Air Pollution (Ink Factory)
2. Secondary Aluminium Smelting.
3. Cost and Use of Personal Air Samplers.
4. Dust Nuisance from Coal Concentration Depots.
5. Sections 58 and 59 Control of Pollution Act, 1974.

The work of the Committee had, in his opinion, proved that co-operation between Districts and Counties was sensible politically, financially and technically and he was sure that there were other joint bodies and committees throughout the Country who found their work equally satisfying and worthwhile.

He had noted that Mr. Robson had made no mention of Noise Abatement Zones in his paper under the Section on Noise and before concluding he wanted to ask him if he would care to comment on his present attitude towards the establishment of Noise Abatement Zones.

Mr. Howell said that he knew Mr. Robson had had some fixed ideas in the early days of the Control of Pollution Act but he was sure he was aware that after a very slow start more and more local authorities were declaring zones and he himself knew of one authority in Gloucestershire who were about to set in motion the machinery for establishing a Noise Abatement Zone.

In Stroud there was a need to control neighbourhood noise, particularly in the area of several industrial estates containing mixed types of industries. He was aware of the practical difficulties and the manpower required for that type of work and was not entirely convinced that using the new, cumbersome procedure in preference to that set out in the nuisance provisions was necessarily the best method, particularly if no attempt was made to obtain a noise reduction where the noise was unacceptable. If that was attempted then of course one ran into the realms of "practicable at reasonable cost" and "would afford a public benefit" etc.

He asked Mr. Robson whether his Department was considering setting up any large scale zones in Bristol in the foreseeable future as part of their policy for the wider control of noise in the community.

Mrs. D.M. Jackson (Bristol C.C.), said that she spoke very much as a lay member. It was the first opportunity she had had of coming to an NSCA Conference, and she was rather hesitant to speak at the rostrum because everyone seemed so extremely knowledgeable. She wished to comment on one of the remarks made by Mr. Robson, who was one of their very able environmental health officers, who worked together as a team in Bristol. He had referred to "first establish the need". This had been shown in the matter of clean air, and the clean air zones. When she was a child she had grown up in the Midlands. At that time there had been a pall of smoke over most industrial cities, and it was eventually upon the demands from the public that the Clean Air Acts had been passed.

They were now hearing that some local authorities had already completed schemes for clean air. Some might say that with the present economic difficulties, much of the programme that had been embarked upon had become too costly. But she posed the question - was it so costly? When talking of the monitoring that they were doing, both in smoke control and noise, they were also discussing people's health. They could not count the cost in monetary terms alone. They must also consider the cost in human suffering. Was it any more expensive than the cost of drugs and medical treatment needed for those who were suffering from chronic bronchitis, lung and other chest ailments? She would appeal to those who, like herself served on Council Committees, to stress those points when endeavouring to get their Council's sanction to finance such measures.

Whether the cost was borne by the District Council, the County Council or the Health Authority, whether it was on the rates, or whether it was on the taxes, as a member of the public she would say that it all came from the same source. They realised that they had their hands set to a job that would have increasing targets, but she did at least think that Mr. Robson's paper had shown that they in Bristol were endeavouring to make some progress in that field.

Mr. H. Nowell (Bath C.C., S.W.Div.), said they were all aware that the general public and in particular politicians were often faced with the choice between environmental protection and economic interests. The former was more often than not neglected, due to the lack of information available and lack of understanding of the subject by those persons. This had been touched on by Dr. Weber that morning and they had now heard from other speakers and read of the use of public relations and community dialogue to further environmental protection.

He entirely agreed with those sentiments, but the magnificent array of Bristol's hardware shown on slide had led him to be a little concerned on behalf of local authorities with comparatively meagre resources as to how it could best be achieved. Could, for instance, assistance be sought from other interested bodies? It was with that in mind that he asked Mr. Robson first if he used the good offices of the Society to help him promote public understanding of environmental pollution, and secondly, whether he felt the Society could do more to this end.

Mr. S.J. Hart, replying to the discussion, referred first to Mr. Evan's suggestion that Alkali Inspectors were always calm, and

were healthy in retirement because they were not worried by elected representatives. Mr. Hart refuted that strongly, by saying that in his case, those elected representatives sat at Westminster rather than the local town hall, but every decision the Inspector made was open to Parliamentary Question, and reference to the Parliamentary Commissioner or "ombudsman" was not unknown.

Mr. Evans had asked whether Mr. Hart considered the number of serving Alkali Inspectors to be adequate, and had suggested a "night shift" for emergencies. Mr. Carson had also commented on the Inspectorate's "limited man power", and the absurdity of trying to serve the country with inspectors in only fifteen districts. He said that in his service with ACAI, he thought that he could honestly claim to have met every call made on him, but he had not been overworked, - fully stretched but not over worked. He pointed out that :-

a. The fifteen Districts covered the entire country.

b. In terms of numbers of premises, and processes, subject to inspection, Alkali Inspectors were already thicker on the ground, and maintained a higher frequency of inspection, than any other inspectorate, either of central or local government. He referred to the comments in his paper on frequency of inspections, and to the Fifth Report of the Standing Royal Commission on Environmental Pollution.

c. Alakli Inspectors were expensive, - a fully adequate work load was necessary to justify the employment of an extra one to the Treasury, to attract the right sort of applicant, and to give him job satisfaction in service.

d. It was a fully adequate work load, covering a wide spectrum of scheduled processes, that enabled each Alkali Inspector to develop, exercise and maintain the wide expertise which appeared to be his most widely valued asset.

e. Every District Inspector's official telephone number was published in the Post Office Telephone Directory, and every office had means of receiving, and recording messages at any time of day or night, seven days each week, fifty-two weeks in each year. At the very least, there was an answering machine service, - that might serve other departments of HSE as well as ACAI, so callers should say that their message was for the Alkali Inspector. It would receive attention at the earliest possible time.

f. The matter of out-of-hours, emergency situations appeared to

him to be grossly exaggerated. During his sixteen years service with ACAI, he had been called out only twice, and in neither case had the police appeared to have any difficulty in locating him. He was sure that that applied to other Inspectors. Most Alkali Inspectors had private home telephones, with numbers in the directory, and they would turn out in real emergency.

Cllr. Lancaster had been concerned about emissions of nitrogen oxides from chamber acid plants, - Mr. Hart said that he would not be bothered any more. Only one plant was still registered, and that was a Kachkaroff tower plant. The last classical chamber plant had closed down in 1973. Emissions from synthetic nitric acid works were being steadily reduced. When he had first joined ACAI in 1959, the presumptive limit for such plants had been a total acidity of the gases discharged to atmosphere not exceeding the equivalent of 3.0 grains SO_3 per standard cubic foot. The limit specified for new works in the latest "Notes on BPM for Synthetic Nitric Acid Works" (1974) was 1,000 parts per million, calculated as N_2O_4, which was equivalent to a total acidity of 0.75 grain SO_3 per standard cubic foot, - a very considerable improvement. But he said we had to be realistic, - nitrogen oxides were produced in many processes other than nitric acid works, e.g. by internal combustion engines, or in any, high temperature combustion process involving an oxidising air supply. There was also considerable production of nitric acid in every flash of lightning. Nitrogen oxide emissions did not look nice, - nasty red smoke, but the problem had to be examined in proper perspective.

Mr. Maxted had been concerned about the lack of toxicological information, on which safe levels might be assessed. The Health and Safety Executive had set up a Toxic Substances Panel, and the assessment of safe levels was a part of their remit. For the time being, ACAI continued to work to their long-standing practice, as described in his paper, of ensuring that the calculated, maximum, three minute mean, ground level concentration should not exceed the Department of Employment's Threshold Limit Value, divided by a suitable factor (30 for most pollutants, 40 for cumulative poisons, or 60 where the TLV is quoted as a ceiling value) to allow for the difference between occupational and residential exposure, and the exposure of the aged, the infirm and the very young. In practice, that worked very well, and he knew of no evidence of any one being poisoned by routine emissions from registered works. He could recall one case of a man sensitised to toluene di-isocyanate, but that occurred at about the time that that class of works first became registrable, and before it had been possible for ACAI to take any effective action.

Mr. Holmes had spoken of difficulties which could arise when air pollution data was published. Mr. Hart himself had always advised caution in the dissemination of such data, but that was a purely personal opinion. He felt that air pollution was an emotive subject, and he had found by experience that many people were only too apt to misinterpret pollution data as usually quoted. He wanted to emphasise the comment made by Mr. Evans on his experience in the formation of liaison committees, that those chosen to represent the general community should be those who "know about pollution". He closed with a little story to illustrate the point, - in 1972, he had written a District Annual Report to the Chief Inspector, in which he had quoted some figures for the total annual emission of dust from all power stations in the Greater Manchester area. He had subsequently asked the typist if she had found any difficulties. She had replied that, once she got into it, she had found it most interesting, but that now she was thinking of leaving Manchester. "Why?", Mr. Hart had asked. She had replied "I don't like the idea of living under 11,000 tons of dust"!

Mr. H.I. Fuller, replying, said that he was in the happy position of being able to say that his distinguished co-authors had answered most of the points he had been wanting to make. Two points remained however. The first on medical information. Mr. Maxted of Hull had been anxious to have better information and had mentioned in particular lead and radio-activity. Mr. Fuller felt that the examples he had selected were not particularly representative in that they were probably among the most carefully researched of any that affected people in the environment. The literature on lead in particular was extraordinarily extensive, going back over 30 years. Radio-activity was a lot more recent, but even more thorough.

It had been suggested that more information should be given to the public. Mr. Fuller tended to agree, but thought that if that was done, as he felt it should be, then it had to be timely, or the public would be very disinterested. On the other hand, he did share with Mr. Hart the fear that too many people were determined to misunderstand information, misinterpret it, even distort it for their own interests. Professor Scorer's 'professional complainer was certainly very well known to industry. But nevertheless, those in industry had to try to make contact with their local 'public' and would continue to try. And in that context, addressing himself to Mr. Nowell of Bath, he said that the Society did provide links between various parts of the environmental world. He spoke as Deputy Chairman of Council of the Society, and could tell

him that the Society organised its Seminars and Workshops and Conferences in an attempt, in a hope, and in the general belief that it did help people to come together to get a better understanding of Environmental Conservation, a topic which at times drove everyone to distraction.

Mr. L.E. Robson, replying to the discussion, said that Mr. D.H. Evans, Chief Environmental Health Officer of Coventry, and Mr. J. Evans, the other Welsh speaker at the session, had both made reference to subjective analysis and complaints. He thought it was probably appropriate to record, as he had not done in his paper, that all of the problems in Bristol had been acted upon following complaints from the general public, or following anticipation by Environmental Health Officers. Subjective analysis did, he emphasised, play an important part in environmental monitoring totally. Reference had been made, by a number of contributors in the discussion, to the formal provisions of the Control of Pollution Act, and the setting up of Committees to consider the information gathered once a Local Authority had used its statutory powers following the Service of Notice under Section 79. He thought it was appropriate to say that his Authority had not yet served any Notices requiring emission data, because they had not found it necessary. Industry had, over the years, provided the Department with information on a confidential basis and this had, as he saw it, prevented the necessity of the Authority to serve Notice. The information which had been provided had allowed them to have a clear understanding of the industrial problems and enabled them to provide suitable comment to the public with regard to local problems. They had also been fortunate in having a multi-disciplinary committee to which he had made reference in his paper on Page 13, Paragraph 6, the "Bristol and District Environmental Pollution Technical Committee."

That particular Technical Committee had not only local but national multi-disciplinary input. The Committee had been set up prior to Local Government re-organisation, and had been in operation prior to the Control of Pollution Act being operative. The Committee looked at all of the pollutants that were present in the Bristol area, or specific pollutants that were considered might be of significance. A mutual trust had been built up over the years because of the long standing of the committee and the way in which it disseminated information by way of technical reports, which he had tried to emphasise in his paper. Information was provided not only at the political level, by way of the Public Protection Committee and the City Council, but also to the community through the local liaison committees which were affected. That trust between the community and the Authority had not just

appeared due to a method of dissemination of information undertaken by the Authority, but only after years of hard work and presentation of technical reports and conclusions to Members and community representatives - irrespective of whether they were politically or publicly acceptable, the facts had to be presented as they stood.

The Authority had found it beneficial to present reports to the liaison groups prior to an issue being formally exploded by way of the media. Mr. Robson thought that in that way the situation would be carefully controlled and it would help to build up confidence with the public, who were being affected by emission problems. That was how they had gone about their task in Bristol - he was not saying that on every occasion it had always worked satisfactorily, but certainly they did not see, at that particular time, the necessity for setting up formal committees, within the terms of reference of the Control of Pollution Act, to deal with dissemination of information. If they were to bring in outside organisations within a formal constitution under the Act, it would put additional overheads on the Local Authority administration, because they would be committed, as a Local Authority, to conduct twice yearly meetings and provide all the administrative backing that those meetings would require, including publishing statements, which he suggested were probably going to be no different to those public statements that should be put out by local authorities anyway.

In answer to the comments made by Mr. Holmes from High Peak, with relation to liaison committees and also the dissemination of information, he appreciated that he had had certain problems in his area and he did not think it would be inappropriate to mention that the group to which he had referred, namely the Friends of the Earth, whom Mr. Robson believed had a very genuine interest in pollution matters, had approached his authority in 1974 and asked if they could be involved whenever a formal committee was being set up. Bristol's answer to them at that time had been 'yes', they would be considered if Bristol C.C. found a need to set up a formal committee. In the meantime, however, the authority agreed that they would put them on their mailing list of every single document regarding pollution matters, whether they were reports of routine monitoring, which were submitted to the Public Protection Committee, or the City Council. The record to date showed that the information had been satisfactory to them. Mr. Robson was sure if they had been dissatisfied with local policies and local results and local interpretation they would have made strong representation to the authority and to his own Department. It was true to say that they had not been hounding the authority and he thought they had been

quite constructive in the area.

Mr. D.H. Evans of Coventry had made reference to the costings of monitoring as set out in Mr. Robson's paper. He wanted to make it clear that the costs he had shown and in fact referred to by way of slides, related to routine monitoring, and did not include the day to day investigations of complaints which were dealt with by his district environmental health officers on the air pollution and noise control teams.

Mr. J. Evans of Rhymney Valley District Council had made the clear point that initiatives and initiation of work, and the programming of work of environmental matters had to be started by somebody. That initiative in most authorities was by the Environmental Health Officers, but they did need support. He could only reiterate the comments which had been made by other speakers, and also elected members of Local Authorities, that officers had to try and educate their politicians, and make them aware of the problems, and of the consequences of their decisions. As far as he was concerned, he was prepared to tell any member of his City Council the results of his department's monitoring activities because he was aware that if he gave them false information on which they might make a wrong policy decision, then he could be sure it would be his own head which would be the first to "roll", and that, he intended, was not going to be the case. Politicians had got to be accountable as well as officers in his view. So, initiative yes - from Environmental Health Officers, they should spur on the politicians and give them the facts (they might be totally unpalatable) but they ought to have them.

Mr. Carson had made indirect reference to decisions that had really got to be based on fact. Mr. Robson suggested that all of environmental monitoring should be used in the production of policy matters, as such policies that were likely to be the foundation for our next generation. The facts that he had attempted to explain relating to environmental monitoring and the manner in which his authority looked at those details, were foremost before the authority could consider any of its policy implications whether in relation to planning, transportation or employment, and that was why he had made particular reference to the close liaison maintained by the environmental health department with all of the other Chief Officers in the authority, and in particular to the relationship between Environmental Health Officers as a profession and the Industrial Development Officer. They were able, not only perhaps in certain cases to put restraints on development, but in a lot of cases to be constructively helpful by pointing out the problems to an industry going into an area and advising a particular

precaution which they ought to adopt. He had given an example of one such industry - a food manufacturing industry that came into the Bristol area, where his department had been able to help them put in a positive filtration plant on their air supply that was being used for the over-ride in bread manufacturing. That had thus prevented the possibility of contamination to the end product. Similar cases, he was sure could be found in most local authorities.

On the planning and IDO aspect, he said it was necessary to consider not only the unemployment situation and the industrial advantages to be obtained from promoting industry in an area, but also to ensure that the work force in new industrial zones were not going to be subjected to health hazards or nuisance, which could be in the form of acid droplet, or other environmental problems, which could cause physical damage either to properties or structures. In that context it was as well to seek, in certain cases, the advice of all branches of the Health and Safety Executive in the early stages of forward planning.

Reference had been made by Mr. Carson to the old out-dated equipment such as the standard deposit gauge. Mr. Robson did not feel quite so harsh about this instrument. He thought that the old standardised type of equipment had to go hand in hand with new refined instrumentation. He said that one must not forget that old types of instruments had been physically monitoring situations for the past twenty or thirty years and were still of use in showing general trends of pollution. It was those trends which had to be related to the current situation and standards. If standards changed, then one could look back at records to show whether or not the pollutant was of significance by current standards. These results were thus reference points and ought not to be disregarded - they were of use.

Cllr. Lancaster of Middlesborough had made reference to his NO_2 problem. Mr. Robson thought it was probably appropriate, not knowing the particular circumstances relative to the nitric acid plant in his area, to comment that there were similar plants in the Severnside area. There was not the similarity in so much that a nuisance was physically being caused, but, together with all branches of the Health and Safety Executive and industry, the department knew full well by their emission inventory that it was the largest nitric acid production area in the whole world, and thus high ground level concentration was a possibility, and had to be properly evaluated. Thus his department felt that by carrying out proper ground level measurements, not only long term trends but also measuring short term fluctuations, especially during the adverse climatic conditions that were often experienced in the Severnside

estuary, they might be able to give constructive guidance to the enforcing authority with respect to gaseous limits at the point of discharge. Some provisional work had been done, not with continuous analysing equipment, but in fact using other methods employed by the department and industry and that had shown that some of the levels which were being experienced in the area were in fact lower than the levels of oxides of nitrogen monitored in busy London streets. He thought that those types of results had to be kept in perspective. He pointed out that cosmetically, oxides of nitrogen looked absolutely terrible - they were locally known as 'the yellow peril', but it had to be remembered that removing the colour did not in itself completely remove the pollutant from the atmosphere.

Professor Scorer had made comments concerning the provision of employment. Mr. Robson thought he had tried to link his comments on that aspect already in his answers in saying that employment obviously had to be linked with industry and in turn that had to be linked with safe working conditions, and of necessity that meant the Local Authority had to examine its area to determine where those safe working locations were, or identify those locations which were not likely to cause nuisance or environmental problems. Professor Scorer had also said that Officers should come clean with their politicians; Mr. Robson wholeheartedly agreed, as he had recorded earlier. He thought that one good thing which had emerged from local government, since its re-organisation in 1974, was that Officers were for the first time being allowed to tell politicians the facts, and those facts were going on public documents, and it was the politicians who were now having to become accountable.

Mr. Maxted of Kingston-upon-Hull had made reference to the lack of toxological effect data, which perhaps could be useful either to the Executive or those employed in Local Authority, and/or to other organisations. Mr. Robson thought that everyone felt there was a lack of data, but that it might be mainly due, not to a lack of efforts being made to evaluate the toxological effects, but perhaps to a breakdown in the communication of the results achieved by various disciplines. As far as his own authority was concerned, he could again mention the 'Bristol and District Environmental Pollution Technical Committee', which had a number of working groups, each looking at a particular pollutant problem. For example there was a heavy metals group, a fluoride group, each of which had experts in their own particular field, whether they were from the Ministry of Agriculture Fisheries and Foods, soil and nutrition experts, Veterinary advisers or Medical discipline, also experts from the company concerned with the emission problem, and from the Department itself. All the multi-disciplinary resources were pooled in those working groups and they had, in the Bristol

area, provided certain general guidelines on pollutant levels, which allowed the Authority to make policy formulation on land use. He had shown in one of his slides, the isopath relationship of fluorides in the area - information which had been obtained both from industries' and local authorities' monitoring. Naturally that had an influence on the Minstry of Agriculture Fisheries and Food and Industries' land use, in respect of designated fields on which animals were allowed for grazing purpoes, including the prescribed type of animals that were allowed to graze there. Something, therefore, was being done at local level. Not an awful lot, however, appeared to be going on at central government level, certainly it appeared that very little information was being correctly disseminated down to Local Authorities and other interested parties regarding pollution matters and policy decisions. Perhaps the missing link had now been identified: communcations.

Mr. Holmes had picked up the question of 'Environmental Emergencies". It could be seen from his paper that these were taken very seriously in the Bristol area. However, he noted that a lot of local authorities did not involve their Environmental Health Officers whatsoever in responding to such situations, indeed he was aware that members of the Health and Safety Executive were also not involved in major chemical emergencies. He said it would be quite incorrect of him to try and reverse the order of responsibility in respect of those situations. The police and fire departments were the co-ordinating authorities, but such disciplines had to have the factual information relative to the premises within their authority, and that information could only be forthcoming from the disciplines who had a statutory function to play, namely the Health and Safety Executive, all branches, and the Environmental Health Officer. In his authority the E.H. Department would respond automatically - they had a 24 hours service in Bristol and responded with Senior Environmental Health Officers who were on call and who were able, provided with equipment and suitable protective clothing, to give technical advice at the scene of the incident, together with all the other disciplines, which included the Water and Waste Disposal Authorities. Their important role in such situations ought not to be forgotten. It was distressing to him to record that most of environmental legislation had been based following major disasters, both in the United Kingdom, and in all countries of the world. Much had been learnt from major incidents, and yet many Authorities still had not formulated a proper emergency plan. He suggested that many delegates at the conference could go back and ask for the emergency plan and be unable to find one in their own Authority. There should be provision for emergencies

and on that particular point he had criticised the Health and Safety Executive in his paper. He had not been criticising the individuals, but the policy of the Executive. They were not, unfortunately as an organisation on 24 hour call; a fact recognised by them. The Association of Chemical Industries had only just appreciated that the Health and Safety Executive Factory Inspectorate were not always able to respond to emergency situations, and yet if one read all the Health and Safety Documents and Guidance Notes to Local Authority, they all stated there would be an automatic response - that, said Mr. Robson, was not the case. Therefore, in their absence he thought that Local Authority members and officers had to ensure that the proper contingency plans were drawn up in association with industry. To complement formal plans, he thought that an informal procedure should be set up directly between the District Environmental Health Officer and local industrial companies. Every single one of the major industries in Avonmouth had by way of voluntary co-operation with the E.H. Department acquired telephone numbers of staff who were proficient in certain prescribed fields of work, and they telephoned the officer on their own initiative, irrespective of a telephone call to the emergency brigade, to advise him straight away of any problems which were occuring, in order that he could respond positively, not only by going to the scene, but secondly by ensuring contact was made, it necessary, with the community through the political level. He could complement his visit after the incident by issuing proper press statements in co-ordination with the emergency service. His Department had found that the practice of issuing proper statements jointly by the responsible organisations of the police, fire and Local Authority and industry, at the scene af the incident, reduced a lot of the residential and community concern.

He thanked Mr. Howell for his comments in relation to the 'Avon, Gloucestershire and Somerset Environmental Monitoring Committee". He thought that the point Mr. Howell had stressed, which was of major importance, was that benefits could accrue from joint projects by a profession over a wide area. He would find it gratifying if some delegates went from the conference, especially environmental health officers, and formed similar committees; committees to be used, not only for carrying out project work, but also on the proper formulation and interpretation of legislation in its widest sense, as it related to Local Authorities. That could be in respect of noise, air pollution, water and Health and Safety matters.

Mr. Howell had asked what his views were on Noise Abatement Zones, and in so doing had put him on the spot. He

thought that Mr. Howell knew his answer. Mr. Robson was not opposed in principle to the government's legislation, which gave Local Authorities discretionary powers to make Noise Abatement Zones. The principal aim was to hold steady, and where possible reduce noise levels in one's district. But there was a big IF, providing that it could be done with the limited resources that were available, and could show a public benefit. In a period of staffing and financial restraints, as certainly applied in his Authority, his own view was that they were of low priority. He thought that the first stage in an Authority making Noise Abatement Zones was probably a political paper exercise, and he was sure that somebody would come back at him with that statement. The first stage of making an NAZ was easy but the second and subsequent stages would be hard work, and very labour and instrument intensive and it had yet to be proved to him that they would be a cost effective exercise for public benefit. He suggested that the existing statutory powers under the Control of Pollution Act in relation to existing premises were probably strong enough if the legislation was used properly. He also suggested that use should be made of the wider legislation of the Local Government Act, and in particular the provisions of the Planning Act. He felt that not enough was being done in respect of planning consents and that more could be achieved. In his own Authority they had just received a successful Secretary of State's decision in respect of a development, which had been turned down chiefly on environmental grounds: noise, fume, lighting and effects on the community. The Secretary of State had backed up the department's views totally in a recent Planning Appeal. He had one encouraging word in respect of Noise Abatement Zones. He thought that they might be of use in areas of new development including inner city work. He did perhaps see a benefit there, especially in relation to new buildings, providing the authority had proficient staff.

Mr. Howard Nowell of Bath had raised the question of the dissemination of information and the possibility of help from the National Society for Clean Air. He did not speak at that time as a spokesman for the Society, but he could say that any reports that his own Authority had considered of benefit - perhaps for wide circulation nationally - had been sent to headquarters and they had been kind enough to put those in their various publications. He thought it would be most useful if more such documents were forthcoming from other organisations and from a wider range of disciplines than those represented at the conference. Mr. Nowell had also referred to resources; Mr. Robson thought that really the point here was whether perhaps the

society could help in the provision of instrumentation. He did not know the answer to that, but he was inclined professionally to make a plea to industry and a plea to national organisations that there could be some formally adopted system in the United Kingdom, whereby Local Authorities were able to pool their resources without the unnecessary interface of high finance coming into it. If one authority wished to complement another in its monitoring work for public benefit, he thought that they should be allowed to do that if staffing levels permitted, but unfortunately at the moment it could not always be done formally because of the current accounting system within organisations.

THE NEED FOR EDUCATION - ARE WE DOING ENOUGH?
RESEARCH INTO METHODS OF INCREASING CHILDREN'S AWARENESS OF LITTER AND SENSE OF RESPONSIBILITY FOR THEIR ENVIRONMENT

D. Lewis and Cherry Mares, Keep Britain Tidy Group

IS ENFORCEMENT OF EXISTING LEGISLATION ADEQUATE?

D.G.T. Williams, Emmanuel College, Cambridge

Mr. T.H. Iddison, opening the discussion said that he thought the traditional role of the person opening the discussion was to be controversial, although he was going to start by agreeing entirely with David Williams regarding the need for the review and consolidation of clean air law, and indeed for much of the other law that effected local authorities generally, and environmental health departments in particular. Having said that, one had to accept that such needs seemed to have very low priority with the Government. Having just retired from local government he was conscious of the fact that about 30 years before, in another field of law, in the Shops Act Legislation, the Gowers Committee had wanted immediate action; and they were still waiting for it. So he was not very optimistic about getting any immediate action.

In his view, once a statute had become law, usually after a very considerable debate at all stages, those responsible for its enforcement, including local authorities, officers and courts, should feel an obligation to implement it regardless of their own views. From that statement they would see that he held the law in very high regard, and he took the view that public opinion should be consulted before the law actually came onto the statute book. Generally speaking it was. The professional organisations usually saw the bill and went through it with a tooth comb at early stages. The press had it; they had the opportunity to put it before the public, and if the public did not want it and did not want to enforce it, then it should not get on the statute book. It might seem that he had been unduly cynical and pessimistic. He was perhaps feeling a little that way. The recent brief definition of a pessimist was - he was the man who took prunes with his all-bran. That was what he had done that morning.

Although Mr. Lewis had rather from necessity confined the comments in his written paper to the effect of education upon litter prevention, one had received the impression that he would have preferred his educational programme to have had the support of some

successful prosecutions. Whilst he had always felt that public opinion might not support tough measures being taken against litter louts, he would be interested to know the authority for his statement, regarding what he had said was the attitude of "the majority of the electorate". He did not feel that the attitude of the public was even tested once it became law. In relation to litter, he spoke about the Litter Act itself and what he called public litter, rather than some of the aspects of other litter, such as cars and things of that nature. He well recalled the publicity that had preceded and accompanied the Litter Act, and how many had anticipated with joy the thought of a cleaner Britain. For a very brief period, during which the more venturesome drew offenders attention to the breaches of the law, things had started to improve. But it had been very short lived, when it had become apparent that no-one had been prepared to prosecute in respect of personal litter. His impression was that the position was now much worse, due largely to modern packaging techniques, particularly confectionery and beverages.

Some of Mr. Lewis's statements implied that all were guilty, and that the scattering of litter in, for example, railway compartments was the accepted norm. Did no-one take heed of the notices in the railway compartment - the illustrated one - 'It's not nice for you - it's not nice for us'? If they did not, then it said little for the value of one form of educational publicity. He believed that there was a small hard core of very litter conscious people, to whom any litter was an abonimation. Thinking in terms of his own acquaintances and getting very close to home; his wife frequently returned home from a visit to the village shops carrying with her a carrier bag filled with other people's litter that she had collected from the road's verges, coca-cola tins and objects of that nature. There was, he thought, a leaven, but it did not seem to work very well.

He was quite fascinated by Mrs. Mares account and slides of the teaching work carried out in Brighton and elsewhere, and he was quite certain that that sort of teaching formed an exceedingly sound base for good citizenship, even if the children subsequently found what they had seen did not accord very well with what their parents did when they were out for a walk.

In the field of air pollution prevention Mr. Williams had quite rightly stressed the difficulty, if not the impossiblity, of making any meaningful comparisons between the successes achieved by the Clean Air & Alkali Inspectorate with its policy of education and co-operation and those achieved by local authorities with a, for the most part, policy of education supported by prosecutions. Their respective problems were a little different in their nature

and in most cases, very different in their magnitude. He said that, despite the sensitivity of some of his ex-colleagues in the larger areas in relation to their own problems of air pollution. Generally speaking, over the country the problems of the Alkali Inspectorate were very different in their magnitude. Whereas the former, that was the Alkali Inspectorate, had one common policy which was to a large extent dictated by the Chief Inspector, there were differences between one local authority and another depending on the attitudes of 1) the elected members, 2) the head of the environmental health department and 3) the head of the council's legal department. It only required one dissentient amongst those three, to make prosecution difficult and two dissentients made it almost impossible.

Nevertheless, the Environmental Health Report for 1976, published by the Environmental Health Officer's Association, which included statistical information for 88% of the District Councils in England and Wales, showed that in that year local authorities had instituted proceedings in 32 cases for dark smoke from industrial chimneys, 93 cases for dark smoke from industrial land, and there had been 22 successful prosecutions in respect of offenses in smoke control areas. That might very well constitute a small proportion of the total number of offenses found, but it was an indication that the local authorities were prosecuting in extreme cases and possibly carrying out advisory and educational work in the others. Undoubtedly there were circumstances in which legal proceedings were inappropriate and even counter-productive. He would whole-heartedly agree with David Williams' comments in relation to acts committed in ignorance. In those cases he was quite sure that the general public would feel that they were not wilful and therefore possibly require a rather less Draconian treatment.

For the wilful offender or the couldn't-care-less offender, a successful prosecution, preferably with a fine big enough to hurt, was not without some educational value. One lesson it taught was that it paid to comply with the law. On the other hand, of course, it might only teach that one must not be found out. He did not subscribe to the view that prosecutions should be reserved for persistent offenders. If a person knowingly offended, he was not entitled to expect to get away with a warning in respect of what might be the first time he had been found out, but not necessarily his first offence.

There were of course some laws that were virtually unenforceable due to changed circumstances. He had already mentioned one - Shops Hours Legislation, and laws that were not properly enforced

for other reasons; those governing speed limits, noise and emissions from exhausts, the driving of untaxed and uninsured vehicles etc. Fortunately most of the clean air legislation, with the possible exception of the emission of smoke due to the burning of unauthorised fuels and the purchase of unauthorised fuel in a smoke control area, had the support not only of local opinion but also of the locally elected representative of the public - not necessarily the same thing.

In a perfect world everyone would comply with the law, because it was the law, and without any justification for it or explanation for it. In a much less than perfect world, it might be necessary to assess the relative costs of education and enforcement and their relative effectiveness. It would, he was sure, be a mistake to believe that once everyone had been made fully aware of all the implications of failing to comply with the law, there would then be few, if any, contraventions. There were some laws, compliance with which resulted in some degree of personal inconvenience, and it seemed cynical that, if failure to comply with it entailed a negligible risk of prosecution, then very little might be achieved by education. He believed that litter prevention laws, particularly the Litter Act, were in this category.

A similar example could be found in the law relating to alcohol and driving. When it was first introduced everybody had become exceedingly chary, lest two or three social drinks would put one's blood alcohol above the legal level and one might be caught out in a random check. He knew that this was so with a number of his friends, it was so with himself, and no-one could be unaware of the frightening implications. Yet in the absence of any random checks there was a well educated public, a poor standard of enforcement, and one might imagine, a high incidence of contravention.

One wondered what successes attended efforts to educate the public on litter prevention in other countries. Mr. Lewis had stated that "None of the 32 member countries in Clean World International considered that enforcement through penal sanctions was the answer". He recalled that somewhere about 7 or 8 years before, a party of about 18 members of the General Council of the Environmental Health Officers Association went on a week's visit to Denmark to look at food premises. When they came back, the main topic of their conversation had not been about what they had found in Denmark, but about how scruffy and littered they had found this country when they came back to it. Did Denmark use the threat of

prosecution or did the Danes respond better to education? One wondered whether there was a national disinclination to abide with, or to follow, education without the force of law.

Perhaps he was being a little unreasonable about it, but he had recently been reading the motoring column in the Sunday Telegraph and their correspondent, Courtney Evans, who had been on a trip to Yugoslavia had said "I found the roads plesantly uncrowded. There are speed limits of 37 miles per hour in built up areas, and 50 elsewhere, except where a 100 km per hour signs give a 62 mph dispensation. The fact that these limits are obediently observed by most drivers, is probably due, in part, to the sharp, on the spot fines imposed on those who go too fast". In contrast, in this country where most people drove cars, how many abided by our speed limits?

Finally, he turned to the questions posed in the title of the papers; "Education - are we doing enough?" As he saw it, education was of value, extreme value in some cases, but only of limited value without the support of prosecutions or the threat of them. If education on its own was not producing results, it was no good just increasing the amount of education. A proper balance was needed between education and enforcement. His impression was, regretfully, that in the field of litter prevention, education without the support of prosecutions had not achieved outstanding success. There were of course some other environmental matters where very much further education was needed. Was enforcement of existing legislation adequate? He felt that, due to the fact that one local authority differed very much from another, overall it was not. In some areas it might be, in some areas it was not. But what he was sure about was, that the Society and that morning's speakers would appreciate everyone's views.

Mr. R. Kidd (Newtown Abbey B.C.), asked whether education concerned with keeping Britain and Northern Ireland tidy should not begin at nursery school stage, if it was really to be worthwhile.

He felt that magistrates should be made aware of the ill effects of illegal dumping on air and health, and that the present law should be equalised throughout the islands and enforced, not just where there was a financial interest.

He wondered why, when an environmental health officer was appointed to a post valued at £x, because he was considered suitable, he should have to start in the position about 3 or 4 increments lower.

Mr. P. Draper (Individual Member), said he was not an educationalist by any manner of means, so he hoped Mrs. Mares would take his comments as intended to be helpful rather than critical. He could not help wondering whether there was a little danger of the enthusiasm on the subject over-emphasising it, and whether too much time could be spent at school on, what one might call, an auxiliary subject.

He thought that there were other ways of approaching the matter. For instance, everyone knew that children loved bossing their fellow children about. Perhaps the idea could be instilled in them that they should be on the look out for other children dropping litter and doing perhaps, not much more than frowning at them so that they got into the real habit of regarding litter bugging as unsocial. This would be preferable to making the subject a very big and deep one, involving all types of litter and what happens to it etc.

Also, speaking as a parent and a grandparent, he could not help wondering about the health hazard. If he had heard that his grandchildren had been sent to examine the contents of litter bins in towns he would be absolutely horrified. He would pounce on his children to see that their children were not treated that way at school. Although they were made to wear gloves, they had seen a little boy in one of the pictures sucking his fingers as all children did. He thought too much emphasis had been given on the examination of litter.

Dr. A. Parker (Individual Member), said that one question raised in the discussion was that of damage to the environment by the deposition of litter on footpaths and roads. It occurred in certain parts of Britain, including the London area, even in places where there were convenient vessels for receiving litter. It was particularly bad where there were large groups of people at a meeting in the open air. Later, someone had the task of collecting and taking away the litter. It could be avoided if young people were properly trained by efficient parents at home and by good teachers at schools. Such deposition of litter did not occur in Germany and would lead to action by the police.

Mr. H.I. Fuller (Esso Petroleum Co.), said he agreed with Mr. Williams about co-operation rather than confrontation. One seemed to be faced with trend towards even more regulations. The E.E.C. had issued over 3,000 regulations last year, which struck him as a remarkable achievement. As a result, it seemed to him

in industry, that they spent an increasing proportion of their time looking over their shoulders trying to make sure they had not done something wrong, instead of getting on with their proper job - making sure they were doing something right. Their proper job, surely was to be making goods rather than worrying too much about who was watching them. Mr. Williams appeared to be very sensitive about the exercise of discretion. Perhaps there was a law there in seeking greater tidiness and less litter.

Air pollution as he saw it was basically a haphazard business. There were so many random unquantified factors, for example, the weather. Certainly things would be a lot easier to control if they could measure and predict everything. Unfortunately this was not so. He agreed however, that control was a matter of attitude. He was sure that the first step in pollution control was good housekeeping. Housekeeping in work, housekeeping in play, as Mrs. Mares would undoubtedly agree. It was an attitude of mind above all - litter tidiness had to be fashionable, as air pollution tidiness had to be fashionable.

Tidiness also had to be feasible, for example by providing litter bins and other arrangements for special disposal. He spent his holidays working on the Talyllyn Railway in Western Wales. It appalled him that having got litter bins, kept empty by frequent emptying into large dustbins, many members of the public would walk right past, dropping sweet wrappers and lolly sticks right by them. It was a disgraceful habit. They took great pride in the railway and tried to keep it clean, and some unthinking members of the public came along and made a mess of it.

He certainly agreed that the materials used for packaging must be carefully chosen. The oil industry, his main activity, was certainly aware of this problem. Those who were old enough would remember how lubricating oils used to be sold before the war in glass bottles. One or two of them would get broken and oil would get on the ground. There would be a tremendous problem of cleaning up oily broken glass. So they had moved to screw top cans. These were expensive and when they had been used the last drops of oil would leak out and the loose tops were liable to get everywhere. So they had had a disposal problem. They had then used cans with tear off tops; still cans, but less use of metal and more economical. He suggested that perhaps cardboard could be used. Empty containers could be burned to recover the heat, but the cardboard could hardly be recycled because of the oil. Perhaps they ought to go back to bulk dispensers as used to happen in the 20s? This would certainly be slower, and there would be a risk

of contamination. The oil industry was very conscious of the problem of disposing of used oil containers and was still looking at the ways to find the best solution. They did agree that awareness and forethought in packaging were required, along with education and co-operation from the public.

He referred to Mrs. Mares paper and said he very much applauded her start with children. He wondered how she could extend it to adults.

Mr. L.W. Groome (City of London), thought that in the programmes dealing with school children it might be suggested to teachers that they themselves set an example of tidiness in the manner in which they left their classroom at the end of a period, such as cleaning the blackboard and tidying up chalks. It had not been his experience in thirteen years of night school lecturing, that the previous occupier of the classroom had cleared up.

He was conscious that many manufacturers now produced goods in containers which led both to increased quantities for disposal and to problems due to their nature and bulk. In the City of London, the "square mile" had a daytime population of about 500,000 and many of these people ate their luncheon in small gardens and open spaces. They created a large litter problem which had to be dealt with largely at night time. A particular problem was posed by drink cans and non-returnable bottles - he had recently been to France where a deposit of 1 franc (about 12p) made most people return their bottle to the shop for re-use.

He asked for comment to be made on the philosophy of a good example being set in cleanliness by the local authority who, after all, could consider favourably meeting the cost of enforcement officers, since this should lead to economy in the cost of collection. He recounted the history of the retirement of a City street cleaner who had referred to the standards of service expected from him in his younger days. The cleaner had been disciplined for missing a matchstick in Moorgate (a long, wide street) and he referred also to his anxiety, experienced after the Lord Mayor's Show when he had but a dust pan and brush and there had been an elephant in the show that year.

Referring to Mr. Williams' paper he had two points to make. He would support the regular assistance of specialists to help magistrates and judges in clean air matters. So far as best practicable means was concerned, surely legislation should provide for a second opinion or arbitration to temper the discretion of

the Alkali inspectorate.

Mr. R.J. Ecob (N.A.C.A. South Africa and Associated Lead Manufacturers (Pty.) Ltd.), said that the N.A.C.A. was the National Association for Clean Air; maybe a little "oneupmanship" not being satisfied with cleaner air, but hoping for 100%! He congratulated Cherry Mares on her efforts but felt that the training of children was grossly undermined by the attitude of many parents. Having arrived early for the conference he had walked around Brighton and seen a lady eating fish and chips discard her paper on the pavement. He had picked it up and said "You've dropped your hankie madam". She had not been amused.

In South Africa they had an organisation known as the "MOTHS" - Memorable Order of Tin Hats - similar to the British Legion. They had placed 200 metre drums at garages where people could deposit any disposable glass containers. These were sold and the money, amounting to thousands of pounds per year, used for charity. There were litter bins and litter bins. The basket type seemed to create more hazard than was intended as litter could be whisked out by the winds. During walks through the charming streets of Brighton he had come across a number of derelict buildings, fortunately many in process of restoration. In the doorway of one shop he had discovered a street sweeper leaning on his broom fast asleep.

In the delightful slides shown by Miss Mares, something had been depicted as "going rotton" and bread as "holy", maybe that was for church use! Penalties for spreading litter appeared to vary from £5 to £100 in different parts of the country.

With reference to David Williams' paper on legislation he congratulated him on a wonderful breath of fresh (or should he say clean) air, relating to nationalisation of the various non - harmonising laws emanating from different bodies. There did seem to be a variation in interpretation of the Alkali Inspectors in different areas. One place had received complaints of noise emission after the demolition of a nearby derelict factory, which had blanked off the original noise. Where additional scarenge filters had been called for, this had also led to an increase in noise emissions to nearby housing.

As an incidental point he said that in South Africa the burning of garden refuse was prohibited because of its contribution to air pollution.

Prof. Scorer had posed the question "Is South Africa as clean as Germany". He had later related to him the efficiency of cleaning ankle deep litter from the Munich Winter Festival by a horde of street cleaners in well under 2 hours!

Mr. A.C. Bazely (London Borough of Southwark), addressed his first question to Mr. Lewis. He could not help but take exception to his remark about spitting being stopped because it was realised to be an anti-social practice. He would have thought that spitting stopped because people did not need to spit! That was because their health had improved. This had been brought about by sweeping and long term public health improvements. The reason people did not spit any more was because they had decent homes and decent work places and the obvious benefits of the control of emissions from work places. They did not get the sort of infections that caused them to spit. And it was not spitting. It was clearing out all the debris from the chest caused by respiratory disorders. Did Mr. Lewis see any improvements which could still be brought about in the matter of preventing litter, by the application yet again, of decent public health principles through the medium of more proper enforcement?

His second question was addressed to Mrs Mares. It was excellent to see what was being done in schools, but he wondered if in her researches, she had come across sociologically significant differences in townships. For example, were certain towns better at preventing litter than others? Were there any good guys and bad guys, and within these townships who were the particular categories of people that were the worst litterers? To what extent could the community do domething to prevent litter in the way that Nottingham Forest Football club were taking a responsibility to stamp out football hooliganism by doing something themselves. Could she make the community and its sense of civic pride respond by doing something about people who littered?

He asked Mr. Williams to what extent he felt that existing legislation was not really being enforced. His belief was that one exposed the deficiencies of existing legislation and the legislative administration by using existing legislation to the full. Why were they not doing it? Was it because of reluctance? Was it because of incompetence or both? Or were there no problems, in which case they could dispense with the legislation altogether.

Hoping to widen the scope of the discussion, he said he had picked up the feeling that technical information which affected the public should not be released to them, the belief being that a little

bit of knowlege was a dangerous thing. Was not enforcement a part of education, and was not education, in part, the giving of information and, if they wanted to make people behave responsibly, should they not be giving them all available information?

Mrs. E. May (Dartford B.C.), said Mr. Lewis in his paper had stated that prevention was surely better than using expenses on wasteful control measures. But education of people would require a programme of mass communcation. She would like to emphasise the word prevention as much as education. Education surely should be based on the premise - do not produce the amount in the first place. Mr. Fuller had already taken the responsible attitude regarding this issue. They had become a nation of throw-aways. Every commodity that was purchased was at least double-wrapped. Whilst insisting on hygiene was it really necessary to have so many wrappers on every commodity that was bought? She did not think that it was necessary. Education she would suggest, should start with the manufacturers of all commodities. If one did not initially receive the vast amounts of litter, there would not be such a problem. She would like to know what Mr. Lewis felt about this theory.

She also said that she thought Cherry Mares project was a very useful one, but again felt the quantity of paper which was produced throughout the project must be vast. She could only hope that her education programme was successful and would not produce more litter.

Mr. E.J. Franklin (Manchester Area Council for Clean Air and Noise Control), complimented the first two speakers on their papers, which he thought were extremely interesting.

Referring to Mr. Williams' paper, he thought he said that polluters were not generally regarded as criminals by the general public. It was his experience that polluters were not regarded as criminals by the Courts either. His Authority had recently had occasion to prosecute a fuel merchant for the sale and delivery of bituminous coal in a smoke control area. They had previously warned this merchant, both verbally and in writing, and sent him details of the boundaries of smoke control areas. They had then heard that he had informed his customers that he was going to continue to deliver bituminous coal, and the local authority could prosecute him if they thought fit. Prosecute him they had. After three adjournments they had got him into court. At the last

moment he had changed his plea from not guilty to guilty, and had then given a long plea of mitigation as to why he had delivered the coal. The Magistrates had found him guilty and imposed a fine of £10. Costs were refused on the grounds that there was evidence that the local authority were persecuting the fuel merchant.

Mr. Williams was of the opinion that Clean Air Legislation should be consolidated. He would agree that existing legislation was fragmented, but if consolidation meant change, he was not too sure that consolidation would be a good idea. Ideally, clean air legislation should have been consolidated within the Control of Pollution Act, but that opportunity had now been lost.

With regard to the Control of Pollution Act and Noise - the continually changing criteria for measuring noise which were being postulated, was a cause of anxiety to enforcement officers. He really did think it was about time they had one standard, a reasonable standard, which everybody used. Mr. Williams had also stated that in his opinion "best practical means" should not be determined by an Inspector, but by a panel of experts. Of course best practical means was determined by the Inspector - it had to be initially, but in the event of a case coming before the Courts, a defendant would have ample opportunity of giving his version of the 'best practical means' of dealing with that particular problem. He saw nothing wrong at all with the Alkali Inspector or the Environmental Health Officer determining 'best practical means' in fact he could not do his job unless he did.

He was not too sure on the point about special courts with expert judges for dealing with pollution cases. There were already too many experts in his view. He thought that lay or stipendiary magistrates were quite able to listen to both sides of the argument in a defended case, and then given an unbiased opinion. He thought experts would tend to be biased one way or the other.

<u>Mrs. R. McLusky</u> (Women's Gas Federation), asked Mr. Williams what he considered small nuisances, as referred to in his paper. She agreed that co-operation was better than confrontation. His comments had interested her very much, and she wondered if untreated wastage from the processing of animal by-products was considered a nuisance, irrespective of the smell. She asked this because she had had personal experience in owning a farm, which was tenanted, on which part of an aarodrome was built during the second world war. The buildings were now used for this purpose. The tenant farmer had an accredited herd and she was sure that they all

knew the strict code of practice laid down by the Ministry of Agriculture and Fisheries for such herds. The seepage of this untreated matter came through hedges, onto fields and was a breeding ground for flies. In spite of many business-like approaches to the local Environmental Health Officer the nuisance had not ceased. She was informed that if one lived in rural areas one must expect these things to occur.

It had continued, and so on a Good Friday morning, when it was pouring with rain, she had telephoned the County Medical Officer of Health, who had enquired whether there were any houses nearby? He had immediately transferred her to the Medical Officer of Health for the northern part of the county, who had joined her on site within the hour. Within minutes he had decided that something must be done. In a few days the tanks had been pumped out, and an order made that this should be done at regular intervals. A close watch was being kept on the processing plant and all appeared to be well. It seemed to her that they were the victims of the 1976 D.o.E. directive to local authorities, to which Mr. Williams had referred in his paper saying, "The small problems caused by the animal waste processing industry have to be balanced against the fact that without sufficient processing capacity, a potentially serious waste disposal problem will arise". She had heard during the Conference Professor Scorer's complaint about noise in the hotel, another gentleman who's golf had been affected by smoke, and now here was an example of a farmer's living, in providing food for the nation, being affected.

<u>Cllr. Denis Lovelace</u> (Bath C.C.), said that he had gained inspiration from the session. He thought that Mrs. Mares had struck a chord which he had noticed at various meetings of the Society during the past two years, which could be summarised by the observation that pollutants were getting bigger! Since he was an elected member and not a scientifically equipped Environmental Health Officer, he was not aware of a particle in the atmosphere. But he was very much aware of a discarded paper bag which blew up into his face. The paper bag was a larger particle - a bigger pollutant - and he was immediately aware of it. He had had the experience of being chided in Moscow (which he had found to be an extremely clean city) for throwing a matchstick away in a street. He had been pounced upon immediately by a lady whose job it was to keep that particular stretch of street clean and requested to pick the matchstick up. There would be no such reaction in this country, where we seemed to encourage people to drop litter.

He would like Mrs. Mares to consider a second project, if she

would undertake it, to discover why people passed by when they saw litter-louts. Only the previous day he had seen, on a London underground train, someone throwing an empty cigarette packet on to the floor - there was nowhere else to put it. If one had refreshments on a train, one had to carry cup, wrappings, plastic cutlery and anything else through the train and either leave it lying on the table or throw it on the floor, because there were no refuse bins on trains. Surely this was encouraging people to take a nonchalant attitude towards litter - having to leave it all lying around for someone else to clear up and take away. In this way society encouraged people to become litter-louts.

The children that Mrs. Mares was helping educate that year would be parents themselves in due time; he had found Mr. Draper's contribution a negative one and would like to disagree with it on the issue of keeping children away from dirt. Children loved dirt. His children came home covered in dirt on every possible occasion and he had come to the conclusion that parenthood consisted mainly in teaching children how to cope with dirt and keep themselves clean. If Mrs. Mares' project helped children to resolve their fascination with dirt and rubbish, she could be making a mighty contribution to easing the litter problem in the future and, as he had said, he had gained inspiration from her description of her project.

It had been stated earlier that legal limitations on litter and other forms of pollution fell down because the police did not have the time to chase every offender. He believed that if they were to go in for a policy of on-the-spot fines this would do more to secure respect for anti-pollution laws and bye-laws than any action in the magistrates' courts, where business was transacted with the velocity of porridge dripping off a spoon. He hoped that those other elected members present, when they came to consider the wide problem of pollution prevention, would persuade their authorities to bring pressure on the government for a further look at the question of on-the-spot fines, so that offenders could be swiftly dealt with at the scene of their offence.

Mr. D.J. Lewis, replying to the discussion said that there had been a very considerable cross country discussion, and it would clearly be impossible in the time available to deal with all the questions in the way they deserved.

He explained that the Keep Britain Tidy Group, as the national agency for litter abatement, worked within the framework of

existing legislation and by the nature of its operation indicated the effectiveness or otherwise of our laws and of the need for amendment and for new codes.

In his view, Dr. Erich Weber had set the tone when he had said that we could not reach the aim of achieving better environmental conditions merely by using technology ... the opinions and behavioural patterns of citizens should also be taken into account ... it was necessary that the citizens should be aware of the objectives of environmental protection. It was those citizens who operated machines ... and making them aware was more promising than passing laws or discussion.

That was very much the position with regard to litter abatement. The Keep Britain Tidy Group defined litter as rubbish in the wrong place. They said 'litter is people' - 'people make litter and people can stop it'. He said that there was no shortage of legislation on litter control including punitive clauses. However, the climate of public opinion was not conducive to enforcement and there was no way of imposing Draconian measures in a democratic country without the people's wish and will. Instant justice in the form of on the spot fines were frowned upon by the Home Office as being alien to the British system of justice and were ruled out on that account.

Education and persuasion were therefore vital ingredients in producing the right atmosphere for the operation of laws and indeed it was Keep Britain Tidy Group's belief that once littering became regarded as anti-social that the need for punishing other than the odd blatant or persistent offender would fall away.

Some would say that it was an impossible ideal. Those who were old enough could cast their minds back to the thirties when there had been signs in public places saying 'Penalty for Spitting £5'. What used to be a filthy habit had almost disappeared, because people had come to regard it as anti-social and not acceptable.

The point had been made that possibly people spat less because they were healthier. For the record, they were just as healthy in the United States of America as in the UK, but in that country they were continuing to spit away quite dirtily, however in the main quite accurately. Such spectacular success in abating litter would not be expected, but he thought it worth mentioning that since the present level of campaign by The Keep Britain Tidy Group started in 1972, independent research had revealed a reduction in litter of 37% over 5 years at 50 typical nationwide sites.

A great deal of the problems in the UK, and the answer to many of the questions and points put forward at the conference would, he hoped, be contained in Section 24 of the Control of Pollution Act when it was, hopefully, eventually enforced some time in 1979. The Act, which had gone through all the Parliamentary processes in 1974, had not yet been enacted because of a general ban on new legislation in the light of economic and financial difficulties. The Section concerned would require local authorities for the first time ever to abate litter, to prevent litter. The top tier local authorities would be obliged to consult with other local authorities in their areas of administration and with voluntary associations within their boundaries.

He said that with regard to litter bin design, the shape, colour, height from the ground, all needed to be locked at. Horses for courses, litter bins in some areas like the seaside resorts where there were seagulls had to be specially designed to keep the birds from getting the litter out. In country areas they had to try to prevent squirrels and rabbits and every other imaginable animal from going in and getting the rubbish out. There was no simple solution to litter bin design. Obviously Section 24 would advance that aspect tremendously and he hoped that overall better systemisation of the process of litter control would also be developed, in time.

On international aspects, he said that the Keep Britain Tidy Group was running the international secretariat of the various national litter abatement organisations established in countries overseas. They had conferences on an annual basis, the most recent one had taken place in the Spring of 1978 in Paris, which some 22 countries had attended. It was a fact that all the countries concerned stressed education and persuasion over and above enforcement. Countries mentioned in the discussion such as Denmark and Germany, and others that had not been mentioned, for example France and even places like Singapore, which had been rather famous for their apparent harsh treatment of offenders, had all come round to programmes of persuasion and education rather than hammering people.

In conclusion, he said that the Keep Britain Tidy Group believed that both enforcement and education were essential ingredients of the litter abatement programme.

Cherry Mares, replying to the discussion, said that Professor Scorer had felt cynical about the effectiveness of education, but she believed that the influence children can have on the

environment and on their parents should not be underestimated. Time and again while working with the project parents and teachers had talked about how the project had made them and their children think about environmental issues. She said that they had seen many examples of children having a positive influence on their schools and on their local environment with improvement projects. She was convinced that children could have an influence on their environment.

She was sorry that Mr. Draper had felt that litter as a topic had been over emphasised. She had tried to explain the fact that the topic of litter was being used as a starting point for an investigation of many other topics. Mr. Draper had said that the project was making litter 'a big and deep subject'. It was not litter that they were turning into a 'big and deep subject', but environmental problems - and she did believe those were enormous. Mr. Draper had suggested that children might be encouraged to put pressure on their friends, but that had been tried. Over the past years the KBTG School Committee scheme had encouraged children to try and control the behaviour of their peers regarding litter mainly by setting an example for others to follow, but that in itself had not been enough hence the reason for the research project.

On the subject of health, she entirely agreed that it could be dangerous to encourage children to pick up litter indiscriminately. She had, however, mentioned that children wore gloves when they picked up litter in the school grounds or playground. Because school playgrounds were swept and cleaned, it was unlikely that there would be anything particularly hazardous there. The children did not pick up litter outside school unless they were authorised to do so. For example the pond cleaning exercise which she had described had taken place under supervision. The children did not pick up litter in the street - that would be indefensible. In The Teacher's Handbook there was a section which stressed the need to tell children to wear the gloves provided in the kit at all times when handling litter and which emphasised dangers to avoid, such as broken glass and dog fouling.

Dr. Parker had asked why there was no litter in Germany - Mrs. Mares was not certain that Germany was indeed free of litter. In fact, the West German Government had been sufficiently interested in the materials produced by the research project to have had them translated and made available free of charge for all their primary schools. She herself had recently been in Germany, visiting the college of education which was using their materials for teacher training and for introducing environmental topics. She had also visited several primary schools in Berlin and noticed litter in

both classrooms and playgrounds.

Mr. Fuller had asked how the influence could be extended to parents. She had explained that they tried to involve the community and influence parents. Of course the Keep Britain Tidy Group was trying to do what it could on a limited budget.

Mr. Groome had asked whether they tried to impress on teachers the need for personal tidiness. There were occasions when such comments could rightly be taken for interference or criticism and she said she would hesitate to go into someone else's classroom - or home and make such a comment. This was, she felt, a matter for teacher training. Various speakers had talked about their experiences in other countries and she wanted to mention briefly the Group's project involvement abroad.

She had already referred to Germany, and the Swiss too were interested in their work. Yet everyone thought that Switzerland was already spotlessly clean. She was working with colleagues in France and Belgium on translating the materials for 10-11 year old children and they were planning pilot studies in both countries to evalute materials in action and discover how they needed to be adapted for the different educational systems.

The South African Minister concerned had recently been in the UK visiting the Keep Britain Tidy Group and it was hoped that the materials would soon be used in South African schools, even though that would involve translation into five languages.

Mr. Ecob had commented on the spelling on one of the slides of children's work. She had explained that the work had been shown to demonstrate that the project appealed even to less able children; she could also show excellent and faultless work done by children without learning difficulties.

Mr. Lewis had asked her to mention that the larger and complicated issues of waste management, packaging, re-use and recycling, energy conservation and so on were under active consideration in the Waste Management Advisory Council and in the newly formed Packaging Council, of which he was a member.

In due course of time those Councils would make their recommendations public.

Mr. D.G.T. Williams, replying to discussion, said that a number of very difficult questions had been posed and several of the

questioners had raised points to which he could not give a satisfactory answer. Two or three of the contributors had mentioned the question of best practicable means. He could only refer them to the 5th Report of the Royal Commission, for a detailed examination of the present procedures used for determining best practicable means. The process of determining best practicable means was essentially consultation in depth with industry, and then a decision by the Alkali Inspector. He did not deny for a moment that it had to be the Alkali Inspector who made that decision. Local authorities in different contexts made their decisions in a similar way. But what the Royal Commission went on to say, and that was the answer to the point raised about who else could do it, was that the process by which the Alkali Inspector determined the best practicable means, should involve a greater degree of consultation, not just with the industry or industries concerned, or with the works concerned, but with professional and expert bodies outside, and the general public or such members of the public as might have views to communicate.

It was not good enough to say that once the Alkali Inspector had made that determination that it could be challenged in the courts of law when somebody was prosecuted for contravention of b.p.m. The problem was that it really was beyond the capacity of most lawyers and most courts, in terms of costs and time alone, to re-open the whole process at that stage. Far better surely to have a properly based, fully consulted determination of b.p.m. Then there would be a more acceptable basis of prosecution in the courts, if that was what was required.

Mr. Iddison, in his very pertinent comments at the start of the discussion had said that he, from his own pessimistic experience, could not see legislation being forthcoming. In other words parliamentarians and politicians did not appear to attach a great deal of priority to the problems of clean air. Indeed the Clean Air Acts themselves were principally secured through the activities of private members rather than through the Government, although of course Government later took up the legislation. He did not think, however, that one could go on simply saying that the law was unsatisfactory. There ought to be a genuine and full-scale enquiry based on the experience in this country and elsewhere to see how far laws relating to clean air, should be consolidated and improved.

SESSION 5

LOW ENERGY STRATEGIES FOR THE UK
Gerald Leach

ENERGY CONSERVATION IN INDUSTRY
Dr. N.J.D. Lucas

Mr. Harry Brown, opening the discussion, said that Mr. Leach had presented what could be called a great paper, which he had openly said was a challenge. Mr. Brown felt that anything openly admitted to be a challenge was worth very deep consideration. He thought that the way Mr. Leach had demonstrated that it was possible to provide for energy requirements over very many years in the future was both encouraging and enlightening. Mr. Brown said that he himself was an optimist, but as a fuel technologist he had to be prudent and assume that there would be a great shortage of energy, so that the efficiency of fuel utilisation would be promoted. If the conditions that Mr. Leach had postulated were to come about, at least we would be better off than if we had ignored the situation. Which ever way things went, the one consistent thing that had to be considered was energy conservation. Mr. Brown thought it ridiculous to spend money in discovering, winning, and transporting a valuable asset like energy in any form and then to waste it, in many cases deliberately, and without due thought, often in complete ignorance of the fact that it was being wasted. He had been interested to hear Mr. Leach demolish the statement which was so often accepted, that gross domestic product and energy went hand in hand. The relationship had been accepted for a very long time.

In the past there had been some proof of the relationship between GDP and energy use. He remembered back in 1946-48 when Dr. Weston had done his researches at the Building Research Station into improved housing. He had proved that fuel utilisation on the whole was directly proportional to the housewife's purse. But Mr. Brown thought there was a great deal in what Mr. Leach had said: that saturation point was being approached in many cases. The automatic machinery and the central heating employed in homes were generally more efficient appliances than they used to be. However, whilst modern appliances had a nominal 70% efficiency, their overall load factor might be so low that their efficiency was much less in practice. Instead of heating just the sitting room, or one room, people were beginning to heat the whole house, and new property was being built containing modern appliances so that a kind of creeping barrage effect was

occurring. That saturation would gradually diminish the amount of growth that could be expected. He thought it was a very interesting point, one that needed to be considered by all those concerned with the prediction of the energy for the future.

Mr. Leach had shown on his table a figure of 8.1 as essential electricity. Mr. Brown had rather wondered what the figure included. He asked whether it excluded resistence heating in homes, which he thought was not a very good practice, and other aspects which could be achieved by other types of fuel.

He felt that Mr. Leach's basis of taking conservation measures on a 1-2 year pay back was very optimistic and he wished it were possible. Many industrialists would probably then be able to find their way to adopt them more quickly. He said that many conservation measures did take a little longer. There was a safety factor built into Mr. Leach's prognosis which had given him more power to his elbow in putting forward his thesis. Mr. Brown was not sure whether the points that he had raised, which he was sure would be explained in Mr. Leach's more detailed report, had included the recession in world trade, and particularly in national trade. He hoped that they had, and he expected that the point would be explained. Mr. Leach had stated that consumption had been held back for the previous 7 years, and Mr. Brown thought there was some justification for it in the report.

Commenting that Mr. Leach had mentioned that industry would make savings on a 22-30% basis by the year 2100, Mr. Brown said that he personally would want to be a bit more optimistic than that. He himself had been, for the last 30 years, and he still was optimistic that there were a tremendous amount of savings that could be made by industry if only they could be persuaded to make them.

Mr. Leach had said that he felt that housing would be covered in terms of loft insulation and cavity wall insulation in about 35 years. Mr. Brown agreed, saying that there were 15 or 20 million houses that could be looked at, some that could easily be insulated, some that could not so easily be insulated. But he thought that efforts should nevertheless be made.

Mr. Leach had expected a 50% reduction in fuel consumption; Mr. Brown said that one of the difficulties in his career was that if he went to a firm or a client and as a result of a detailed survey, he told them that they could save 1.392% of their fuel bill, the industrialist would be very glad to sit down and discuss it and

believe him. If, however, he was to tell him that he could save 30% or 40% or 50%, he would not believe it. He just could not believe that he had been making a profit for the last 30 or 40 years and still throwing all that money away. That applied particularly to the so called more canny areas of the country. There seemed then to be a psychological barrier for industrialists and other people against believing that savings of 30% or 40% were possible. He had had two cases where that was clear from a one day visit two weeks before. Personally, he did not think his estimates had been believed. But such savings were indeed possible. He believed that a 50% saving was an obtainable target in most homes today. He was achieving that in his own house. He had taken readings for over 10 years, he was approaching the matter on a scientific basis, and he agreed entirely with Mr. Leach. He suggested that everyone should agree with him, and if only 300 people were to take action, at least that would be a start.

The results that Mr. Leach had been putting forward would obviously be explained in more detail in his lengthy review, but Mr. Brown agreed that from the final graph he had shown, the fuel used in the commercial and industrial fuel industries could be substantially reduced to give a great contribution to reducing energy needs. He suggested that the amount of energy used to keep a scantily clad typist with a light blouse, of flimsy material, in an office at about 75° or 78° fahrenheit was extortionate. The thermostat for the whole building was often placed so that the typist could control the temperature, which everyone had then to endure.

He said that it should be borne in mind that every 1° Fahrenheit by which that temperature was reduced gave a saving of 3 or 4%. If a reduction of 4° or 5° fahrenheit was made then there would be an immediate 15-20% saving with the possibility of a bigger output in production. On the question of domestic hot water, and he used the word 'domestic' hot water in its commercial context in offices, not in the home, he felt that where there was a boiler and with a cylinder allegedly storing hot water, it was not storing hot water at all. It might be storing the water, but it was certainly not storing the heat for use. The amount of heat that could be got out of a cylinder was determined by the sensitivity of the thermostat which was usually ± 3°, 4° fahrenheit. He explained that as soon as the thermostat called for heat and the boiler started up, it was working on almost instantaneous supply. Systems were still being designed to this old tradition which had been developed quite by accident from the old days of solid fuel, when sensitivity of burner performance could not be obtained. The whole design needed to be reconsidered. It did not matter

too much in homes because water temperature was not too critical at any given time. In commercial offices and in hotels however, every next user was entitled to water at an equal temperature as the last. It was a point well worth thinking about, and a thing which should be modified to save a tremendous amount of energy and also of resources in copper for copper cylinders and a great deal of extra boiler power which was still being provided.

He felt that altogether, Mr. Leach's paper was a sample of what promised to be a very fine report. He had been particularly interested at the end of the discourse to note that Mr. Leach had mentioned wind, wave, and solar power, and as one of the 11 people who had formed the Solar Energy Society of Great Britain, he was very pleased that Mr. Leach had given it due consideration but had not been over-optimistic about what could be obtained from those sources. He said frankly that in comparison with lots of sources of energy that had been proffered in the past few years, the amounts from those sources were comparatively small, indeed almost miniscule compared to overall energy requirements. He excluded, naturally, all new technologies that could not yet be predicted.

His last point was that people talked in terms of £billion for replacement of generation plants, mining plants for coal, etc, etc, and yet only £20 million was allocated for conservation measures, having been recently increased from £10 million. The fact was that if an average, and an easily obtainable average, in the view of most enlightened people, of 30% could be saved, most energy problems could be solved at a cost that was a very very small fraction of the cost that would have to be invested in order to win, convert and distribute extra energy to the user.

<u>Professor R.S. Scorer</u> (Individual Member), said that it had taken him five years on the local council to get the borough architect and engineer to look into how much could be saved by insulating schools and other public buildings. Their study had shown that by spending £100,000 they could save £50,000 a year on fuel. When the second year had come the "cuts" had been imposed and so they had said that they would only spend the £50,000 which was being saved as a result of the first year's investment. They had not been susceptible to the argument that a much bigger investment would be highly profitable, and had used formal arguments about not spending revenue on capital projects, and not being in business, to justify such improvidence towards the future. Indeed they had implied that elected members, and Professor Scorer in particular, did not understand the very sensible rules under which

they worked. They were not allowed by the rules to make assumptions about probable fuel prices in the future, and the majority of the council would not instruct them to give priority to securing the future.

At the domestic level too formal economic arguments were allowed to be paramount. Professor Scorer had saved a large fraction of the cost of a 3-wheeled car he had bought in 1973 because of his expectation of rising fuel prices but that was not all that was involved. In the case of rather expensive exterior insulation for houses with 9 inch solid brick walls a house owner ought not to be put off by a calculation of how long it would take for the fuel saving to pay for the investment. An important aspect of a whole way of life was involved. Not only was it a choice rather like choosing furniture and decoration for which one did not do such a calculation, but it was also an aspect of freedom in the future.

Mr. P. Draper (Individual Member), thought that a lot of valuable information was being made available and that insulation of buildings was one of the greater means for saving energy. He was rather surprised by one of the graphs purporting to show how much would be saved in the future, or how much it was estimated would be saved in the future by such things as solar, tidal and other means of obtaining replaceable heat. But he said that the trouble with all those forms of energy was that they were very capital intensive. He had looked into the question of solar heating in his own house, but it was not much good to him that he would only recover his capital in 30 years time. On the other hand, he used a solar heater for a swimming pool, but was able to make his own unit quite inexpensively.

With reference to other means of saving heat he was surprised that so far nothing had been said about the saving in heat losses from power stations in the U.K. When thousands of tons of fuel were put into power stations they contained a certain amount of heat. But it was less than one-third of that heat that could actually be used from that generator. Where did it go? He said that there was one loss that could not really be avoided, and that was the loss in the power lines conducting it from the station to the home. That loss had to be accepted, because were there to be cables of larger dimensions that did not involve so much power loss, the price would be prohibitive. It was staggering to realise that two-thirds of the heat in the fuel that was being bought and used so expensively, was just dissipated into the air. If that could be saved from all power stations in the country, far

more heat would be gained than all the other methods that were being considered, which involved a little bit here and a little bit there. He explained that the known way of saving most of that heat was to use district heating from the power station. There were all sorts of technical and economic difficulties involved, but it could be done and was being done in some cases, (hardly at all in England) and he thought it was quite scandalous that that heat was being wasted.

One of the technical troubles was that the heat that was being lost was the heat from the steam out of the turbines, low grade heat with a relatively low temperature and, therefore, not too easily usable. Heat pumps had been mentioned in the discussion. They provided an economic way of pumping up the temperature, so that quite high value heat could be gained by using heat pumps and then perhaps generating more electricity. There would be all sorts of ways of using that power which was being lost, and he thought it shameful to be heating up the atmosphere with two-thirds of all the oil and coal which was being put into power stations. If it were being looked at by someone from outer space, it would be regarded as scandalously stupid.

On the point to which Professor Scorer had previously referred, outside insulation of house walls, Mr. Draper considered it a sound idea on which he was just embarking himself. His own house was a wooden one with cavity walls. He was applying a third layer of timber on the outside with some sheet polystyrene insulation between. That was another way of effecting a small saving.

Dr. A. Parker (Past President & Individual Member), said that he had listened with great interest to the opening address at the session. The first speaker had shown a number of diagrams giving their minimum and maximum estimates of energy consumption over a long period. He himself would not live long enough to know whether or not the estimates were correct. Nuclear energy had been mentioned. That form of energy could be made very efficient with well designed and well operated equipment. There had been no mention of the possibility of using energy from the earth. He said that the centre of the earth must be very hot, at temperatures much greater than at the surface.

He pointed out that there were several parts of the world where there were hot springs of water at the surfaces, although there were none of real value in Britain. In some instances, hot or warm water was being obtained by drilling some distance down into

the earth with pumping of the water upwards, with some examples even in Britain.

Energy was also being obtained in some places from the flow of water from the land into the sea. He said that there were some parts of the world where there were great areas of sea with some of the sea water warmer than the adjacent sea water; but they were too far away from occupied land to make it economic to transport the warmer water to the land.

Mr. E.B. Briggs (BP Oil Limited) said that Dr. Lucas's paper contained two main aspects - technical and political. In his view there could be little argument on the technological issues and the order of energy savings outlined. Much of this had been well established over many years.

With respect to the political areas, and especially the financial investment aspects, he wished to broaden the perspective and suggested that an apt title might have been "Energy Conservation in Competitive Industry". He stressed the wide range of criteria applied by accountant management to financial investment schemes. In a highly competitive situation where profits, in some cases company survival, were vital, there was a definite order of priorities largely deriving from the rate of return available from each individual scheme. Schemes must compete, each with the other for the limited capital available. The complex inflation pressures of recent years added to the difficulties. In today's world, the competition within any organisation or company for capital for projects must cover a wide range of activities to meet, for example, legal requirements and also production requirements.

Energy-saving schemes are often well down in the queue for such capital because they have no 'legal' priority and often give only a mediocre return on capital. Furthermore, where the energy bill was a significant or large proportion of production costs, energy usage had usually been scrutinised and minimised over the years to maintain minimum and competitive production costs.

Under the heading "Recent Government Policy" the paper referred to the new Government Grant Scheme providing £25 million for funding a proportion (maximum 25%) of schemes submitted for approval. This scheme, it was hoped, would result in a total capital investment of £100 million for energy conservation schemes. He queried whether such monies would, in the current climate which already demanded very heavy investment for production, environmental or industrial relations schemes, promote and develop energy saving schemes on a wide scale.

Mr. I. Holmes (High Peak B.C.), posed his questions on the assumption that insulation of existing buildings would play an increasing part in energy conservation in the future. Assuming, he said, that performance in the field of insulation and energy conservation was related to be quasi-mathematical formula of Performance = The Technology being available x our motivation to apply it, how would the motivation to apply both existing and new technology be stimulated. He asked whether it would be by rigid enforcement of new legislation or by a policy of encouraging the public through education or by both.

If, for example, energy conservation committees were to be created at a local level to promote energy conservation, he felt that would be a step back in time. He was reminded of the question that "a committee is a quiet avenue into which good ideas are often lured and quietly strangled".

As the sub title of the conference was 'Ways and Means' - by what means and which way, he asked, would energy conservation actually be carried out in the future - on a national basis in a big way.

Mr. Harry Brown (Individual Member and Energy and Resources Consultant), who had opened the discussion, agreed to present Dr. Lucas' paper, as at the last moment, Dr. Lucas was unable to attend the conference himself.

Mr. Brown had tried to be contentious in opening the discussion, but fortunately found himself in broad agreement with Dr. Lucas' paper. He did not propose to read the paper, but wanted to bring out certain points which interested him, and which and he hoped would interest the audience, in the full knowledge that delegates at least had the written paper which they could read at leisure. He said that he would at certain points quote verbatim.

The author had introduced the paper by saying that the conservation of energy in industry was an extremely complex subject, depending as it did on the details of energy used in the wide variety of industrial processes and depending, as it also did, on the motivations and actions of plant manufacturers, industrialists, civil servants and politicians. The obvious way of beginning to classify the material was into two broad categories - technological possibilities and political action. Mr. Brown thought that Dr. Lucas had been right to draw attention to that in the first instance. He had reviewed activity in terms of the technological possibilities in the medium and long term, in a way in which Mr. Brown thought everyone was familiar, with good housekeeping in

the immediate term, such as replacing window frames, turning down thermostats and so on.

While in the medium term, he had referred to modifications of existing plants or even the plants on the drawing board and then finally in the long term, changes in process design, probably only practical with the next generation of plant. Mr. Brown thought that a very important statement, because later on in the paper, Dr. Lucas had gone on to discuss the way in which the design of plants determined the energy usage of the plant. Mr. Brown said that plant was being purchased on the lowest capital cost, generally - the cheap and nasty versions as far as he could understand - and the only way that could be avoided was by drawing up a very complicated specification. Very often people found that they did not get what they had originally wanted. One of the most important aspects he himself had found was that a tremendous amount of the equipment and systems that were still being used in industry were antiquated in design. They had been developed through the ages rather than been designed for modern requirements. He asked generally how much insulation there was on an electric cooker, or a gas cooker, or how much on a refrigerator. Was it enough? When account was taken of all the hotels and canteens using ovens where heat was being given out through uninsulated equipment, and then money had to be spent to draw out that heat by ventilation equipment, the situation became ludicrous. At the HEVAL Exhibition in Birmingham where he had done a survey of all the stands of firms who were supplying modern high-efficiency equipment, he had looked at the equipment and then asked simply where the insulation was? In every case, he had been told that insulation was not incorporated. When he had asked why not, he had been told that manufacturers were never asked to insulate the equipment. They were supplying to contractors who had to get jobs on the cheapest possible tenders so the manufacturers actually took out the insulation! If people asked for it, they could get it. That, he said, explained one of the important points which had been made in terms of design.

Systems were being designed as they had been 20 or 30 years ago, albeit with certain controls added which very rarely continued to work anyway, and with very little thought given to whether those systems were correct for particular applications. Mr. Brown had quoted a case previously, on the domestic hot water heater as supplied in public buildings and generally throughout the country. He said that there were very comprehensive curves in the appendices of Dr. Lucas' paper, which illustrated those points. Dr. Lucas explained the curves in his paper and Mr. Brown thought that if it was read with the intent that it deserved, the significance

of his argument would emerge.

The basic argument was that simple methods of insulation could save a tremendous amount of money. Mr. Brown stressed that insulation was comparatively cheap, but that that was only one aspect of the story as he saw it. One of the important things was the design of equipment to suit the load that that equipment was due to handle. For instance, with a school, or a town hall or a factory or an office, boiler plant was designed to suit the winter time load which was probably three times the Autumn and Spring load. Two boilers were often installed in that case. The designer installed them on say 60%, 40% of maximum load. Both boilers were then often operated irrespective of weather. Even when one boiler was working both boilers were often kept warm even when the weather was warm. The reason for that was because the requisite values were not available to isolate the one from the other. He himself had seen an instance where 16 boilers had been put in on a modular basis in order to provide the very very accurate step up to cater for weather variations, but in practice they could only be isolated in blocks of 8. So it was back to 2 boilers again. It was basic design re-thinking that was required; if the paper was read with that in mind, it was very valuable.

Dr. Lucas had quoted specific figures. Mr. Brown was sure that these figures had been developed by experiment. Other figures that Dr. Lucas had brought out, in terms of insulation of boiling pans in industry and different designs of boiling pans to make tremendous savings, had been based on actual trials. Dr. Lucas had stated on page 4 that obviously the details of the calculations and possibly even the experiments could be disputed. The basic contention that very large savings were possible by a combination of insulation and heat recovery could hardly be in doubt.

Dr. Lucas had referred to the question of discounting rates, in other words, how people could check up on how conservation measures would repay them. Was it, he wondered, to be taken according to the present day value of fuel or should some other fuel costs be foreseen in 5, 10, 15 years. All Mr. Brown was prepared to say about that was that he was thankfully not an accountant, but that energy conservation was well worth doing. If it was found to be difficult to make these calculations, then there were discounting tables that could be obtained from the Department of Energy on various bases which were well worth while applying for, and using. The author had emphasised that he did not want to labour the question of design and insulation and their effects except to summarise that the studies of his conversations with manufacturers had suggested that little notice was taken by the

purchaser of any piece of equipment, of the energy consumption, even on energy intensive plant.

Mr. Brown said that as an interesting exercise, one could assume that one was buying a boiler, a furnace, or a motor car, and compare the capital cost with its energy using capability throughout its life. The energy consuming potential of a boiler, even though capable of efficient operation, cost a great deal of money compared to its capital cost. He said that Local Authority officials, in particular, would be well advised to look at the total capital plus revenue cost of any equipment to be installed.

Dr. Lucas had referred to combined heat and power. He had raised again the fact that, in the past, it had not been possible for a small seller of energy or a small potential seller of energy to sell it to the C.E.G.B. on anything like profitable terms. Dr. Lucas had felt that the position might be clarified as Dr. Walter Marshall's Report was soon to be published. From his own professional life, Mr. Brown could think of factories that could have produced energy, and could have provided schemes that could have been blended into the National grid but for the financial constraints laid upon them by the C.E.G.B. It had nearly always been found to be financially unacceptable, whereas thermally it would have been very acceptable.

Dr. Lucas had discussed in his paper the inhibitions of industrialists in accepting energy saving put to them. Mr. Brown had referred to that earlier, when he had said that they were dubious about the 30, 40, 50% savings, but they were quite prepared to talk about smaller savings. Dr. Lucas' contention had been that they were affected by one or two other factors. One was uncertainty, the other was a preference for their own line of business. In other words, if they were experts in making nylon stockings, they would continue to make nylon stockings and not worry about the small fuel cost. Mr. Brown said that where fuel costs were a small percentage of total turnover, the saving of 20 or 30% in the fuel bill was a comparatively small amount of money. Nevertheless, it was often a significant contribution to net profits. What was not spent was equivalent to net profit. It was wrong to look at it in terms of percentages of turnover. If the Managing Director had already got a Rolls Royce, it would mean that he could buy his wife one at the end of the year as well. He said that the author was pleading for people to take a closer look into these points, which could be put to them in very specific terms. He had pointed out the facilities that the Government were offering in terms of services of consultants,

services of Government Departments backed up by certain amounts of money to help in this conservation campaign.

He suggested finally that all those who were responsible for installation of equipment should immediately review the design of plant, and demand high insulation standards. He referred to the position in terms of heat exchangers for air conditioning. How many air conditioning units, he asked, were crammed into cold plant rooms, in hotels and offices, where they were uninsulated. The same applied to boilers. It was also necessary to have commissioning standards, whereby once a plant was installed, it would be duly tested and commissioned to ensure that it operated at various load factors, at a specified efficiency. It could be done. As a result of legislative action, the press now carried statements about motor car performance.

Mr. Brown felt he should explain that the conservation campaign was nothing new. The official conservation campaign in the U.K. had really begun in 1945, and it had had a chequered history. In 1947 with the miners strike people conserved because they had to, and then forgot about it. After the Suez crisis, people forgot again, and then when eventually the '73 crisis had come along, and after that, people could not afford to forget again. In the '73 crisis, a very efficient organisation had made great efforts and saved an additional 16% of energy. They were no longer saving that 16% of energy because the effort had been relaxed.

All the points made in terms of commercial priorities were illustrated by the results of the Government's own Property Services Agency. They had made great efforts and were in fact attaining 30% savings mainly by virtue of using adequate and improved controls.

Mr. Brown turned to the final paragraph of Dr. Lucas's paper which he believed was something that affected the N.S.C.A. Dr. Lucas had indicated that the measures announced by Government would have effect on all but one of the obstacles to efficient use of energy. Whether the measures would be adequate was perhaps a most point, but one very persuasive aspect remained quite untouched: the consideration to which Dr. Lucas had given the title 'energy use of the designed variable'. That was to say, improving the design of equipment to burn less energy right from the start. None of the measures so far announced would make manufacturers design more efficiently, or make consumers buy more effectively, to give more efficient plants. Mr. Brown said

that Dr. Lucas had suggested that Government should legislate against poor performance standards for plants but that he had thought that to be impractical. In Mr. Brown's view however, it was very practical, as demonstrated by the National Society for Clean Air at the time when it had been thought by many to be very impractical to have a Clean Air Act. At that time, it was thought that no one could stop the smokey chimneys of England belching out their filth. Britisher's lived and thrived on it, but after a long campaign an Act had been passed. He believed that the very same Clean Air Act, which depended on cleaning up combustion, and thus improving efficiency, had been one of the major forces that had helped conservation of energy in the U.K.

It had been said that control would be difficult if legislation were made to control energy efficiency but there were a great number of very good plain clothes policemen in terms of those people who did the approving for plants under Clean Air legislation. They had been trained to look at industrial activity from the environmental aspect.

He firmly believed that with a little time and trouble energy saving measures could be formulated in legislation. He did not think that the National Society for Clean Air's promotion of the Clean Air Act had caused rioting in the streets. Indeed it had been sc successful that he had to show pictures of what it used to be like before the Act so that people could appreciate what Clean Air really was. Dr. Lucas had said that the energy scene was an area where one could expect initiative from the engineering institutes. Mr. Brown explained that the Watt Committee was a combination of 63 professional institutions who were directly concerned with advising Government on energy matters, and he hoped that an educational programme would be announced before the end of this year, which would be comprehensive from universities to the general public.

Mr. Leach, replying to the discussion, said that the first comment about his talk had been made by Professor Scorer. He had said that he was putting some expensive insulation in his house, and drove three-wheeled light-weight cars. Mr. Leach thought that was splendid, and explained that in the energy forecast he had described, they had assumed that some people did that kind of thing. But they had also been very cautious about how many people were motivated in that way. One of their emphases was that most energy savings were done for people, partly by technical improvement and partly by Government leadership in spending money.

The second comment had come from Philip Draper, who had asked why the energy forecast had been so moderate about solar, wind and C.H.P. Mr. Leach said that he himself was very enthusiastic indeed about all those things. He was indeed a member, like Mr. Brown, of the Solar Energy Society. He knew Steve Salter, who was developing his wave energy "ducks". He had spent some time in 1978 helping on a critique of the Government's Energy Paper on C.H.P. But he also had pinned by his desk a notice which said "you cannot have cake and jam and cream, except at the Ritz". In the forecast, they had a lot of cake and jam and cream in terms of energy savings techniques, but one could not have them all together - unless one was exceedingly rich. He said that if it was assumed that houses are well insulated, if they also had efficient heating appliances, or heat pumps, the fuel bill would drop to a very low level indeed, even with a doubled energy price. With the average flat, with the insulation and the efficient appliances that had been assumed the fuel bills dropped to £10 - £15 per year. That did not make a further energy-saving option such as C.H.P. very attractive: it was a case of either, or. That was part of the answer about why they had been rather conservative about combined heat and power. The other reason had been discussed in his talk. They had wanted to avoid "solving" the energy problem by assuming lots of solar, wind, wave, geothermal energy, and lots of C.H.P. Several forecasts of that kind had been made in the U.K.: for example, by the National Centre for Alternative Technology, in Wales, and by Friends of the Earth. He wished such forecasters well; he felt that all those things ought to be furthered. But it should be realised that it was politically dangerous to base a forecast that was trying to change people's perceptions of what could be done on very optimistic assumptions about as yet untried, unproved and uncosted technologies.

Dr. Parker nad made the point that all forecasts turned out to be wrong in the long run. Mr. Leach agreed. But he said that that missed the point of what forecasting was for. He said that forecasters look ahead to try and see what should be done in the present. The I.I.E.D. forecasts were trying to make the point that the energy future did not have to be one of fuel growth. It could, by a whole series of changes, be one of zero energy growth. Once that point was made, it altered the way that everyone saw the future, and it therefore altered policy.

The last comment had been made by Mr. Holmes, who had produced the equation: Conservation = technology x motivation. Mr. Leach asked how it was possible to get conservation going which he thought was part of what Mr. Briggs had been talking about. Referring the question to the I.I.E.D. Report he said that they

had made two main policy assumptions. One was that the Government was willing to set energy consumption <u>standards and targets</u> in quite a short list of very important items. Those included regulations about heat losses in new dwellings. Those already existed, in the Building Regulations, for new houses, for new offices, and in 1978 they were introduced for industrial buildings. Then there were energy performance standards for vehicles, especially cars. The real point there, was that industry was waiting to go. A large book produced in 1978, written by 13 Scientists at the Shell Thornton Research Lab, had piled up the evidence of what could be done to save fuel in vehicles and concluded that a reasonable target for the European car, not the American gas-guzzler, was a 50% improvement within 10 years: a move from about 30 to 45 miles per gallon on average. This assessment ignored several important technologies, including continuously variable transmission, which could add a further 10 miles or so per gallon. Industry would like to move in these directions but they did cost more money, and they were reluctant to go it alone. If there was Government discussion with the motor industry about this he thought one would get, moderately easily, agreement on future performance standards, as was done for vehicle emissions in America a few years ago.

Next, there were energy performance standards for major household electrical goods and cooking stoves. Harry Brown had mentioned insulation on refrigerators. When people bought a fridge, or a cooker, few really cared about its energy consumption. It was not a big item in total household bills. People went for colour, the design and trim, or fancy controls. But there were now several studies that showed how, by better insulation, better heat pumps on refrigerators, better door seals, and many other quite small design changes, one could with all the big electricity-using goods, and with gas and electric stoves, cut fuel consumption to a half. The extra capital costs would be paid back in about one year, through lower fuel bills. So there was a strong case here for setting performance standards and targets, introduced by Government in discussion with the industry.

None of these measures should affect freedom of choice - something that was always raised in this context - because very few people either knew or cared what happened inside the hardware they used, or the fabric of the buildings they lived or worked in. None of the measures that others were suggesting went beyond those that were widely accepted for the common good, including the Building Regulations and the Clean Air Acts.

The other range of policies that they had assumed was that

government and the professions worked to provide better information: in information for the professions, such as architects, and also for the consumer. This policy thrust was beginning to move very rapidly. Apart from information, there must of course be financial support for energy conservation. Again, this was moving ahead and increasing quite rapidly in the U.K., although we were quite a long way behind some other countries.

Mr. Harry Brown, replying to the discussion on behalf of Dr. Lucas, said that there had been only one question, from Mr. Briggs, which he would answer, but that he would also refer to Mr. Holmes' point. Mr. Brown was himself a native of the High Peak district and so claimed the privilege of reply.

He explained that, in the most friendly way, Mr. Briggs and himself were old adversaries. Mr. Briggs had been absolutely correct when he had mentioned the importance of finance in competitive industry. Everyone was all too well aware of that. And of course finance was difficult for public authorities as well. Mr. Brown did not know how Dr. Lucas would have replied to the question. He himself would answer with the facts as he knew them.

The previous year, he had visited many sites belonging to one organisation, all small sites but with a total fuel bill of £1½ million. At each of those sites it had been discovered that boilers were operating in twos and threes without being shut off, irrespective of whether the requirement was for one, two, or three boilers. Standard control panels had been put in and never maintained, the fuel consumption was not known, etc. A saving of at least 20% could have been achieved simply by good housekeeping. He had reported the possible savings to the management, who had immediately allocated £150,000 for improvements, conditional upon the money being spent by 1st October - and that had been at the beginning of August! Thus there had been engineers rushing around trying to spend money with little time for thought.

Another firm he had visited the previous month had been spending £6,000 per annum on keeping an oil-fired boiler hot, in case the gas boiler failed. They had been throwing condensate away from a process plant, which amounted to 700 lb of steam per hour, which was equal to 10% of the steam cost.

He said that there was in existance an Energy Managers Club, to which he hoped many of the audience belonged. There were, he thought, over 44 organised groups in the Country. He said it

would be nice if every Energy Manager could organise an Energy Account in his own firm so that what he saved during the year would be available for energy savings which might need some capital expenditure in the future. It would seem that Derbyshire County Council Education Committee had started something by making available a proportion of savings to those who made them. In that way, he thought it possible to get people to organise and motivate themselves to save energy. It was on that thesis that he himself had worked. By such means, he believed it was possible to raise capital from waste. The saying was that God helps those who help themselves!

Combined heat and power had been mentioned, but in the UK combined heat and power had to be considered in a place where it could be installed and operated economically. Where a new town was being built, or in a new country, the situation was different. It could be that there was a future for it in the inner city areas of some of our major towns, which could be rebuilt on a combined heat and power basis. Mr. Brown reiterated that very few people knew their total fuel bill. The first thing to do was to know what was being spent on fuel. The second thing was to find the fuel bill of each unit, be it a school, a Town Hall, refuse disposal place, or whatever. It was necessary to discover how much each unit was burning, and to make sure that they, the operators, were made responsible for informing the Authority of the result each week. The Authority should keep the records, and having done that, should compare them, preferably in Degree days. People should question whether any windows were open, whether the boiler was operating correctly, whether the burner was clicking on, clicking off many times, and if so, they should do something about it.

He closed his remarks by saying that Lancashire County Council had, ten years or so ago, saved over a million pounds a year by doing that simple first operation and then improving their method of fuel utilisation.

Dr. Lucas, in a written reply to the discussion, said that he was grateful to Mr. Brown for introducing his paper at the Conference.

Mr. Briggs had asserted that the technology of energy conservation was well known; Dr. Lucas entirely agreed. There had in some areas been a move away from conservative design. Nor could he differ from Mr. Briggs' observations about capital stringency, and indeed he had tried in his paper to show how large energy savings in moving to optimum practices would only result in a small decrease in the present worth of costs and yet of course would in-

cur significant incremental capital expenditure. There was probably little that could be done for an industry that earned no profit at all; in other cases he could see little alternative to the policy of incentives and education which he had suggested.

SESSION 6

THE ECONOMICS OF CLEAN AIR
Julian Lowe, University of Bath

AIR POLLUTION - THE COST OF ABATEMENT AND CONTROL
A.W.F. Maule, Environmental Health Department
City of Sheffield

Mr. Max Beaumont, opening the discussion said that the papers indicated the enormous cost of clean air, and as Chairman of the Environmental Protection Equipment Manufacturers' Association it was of no great surprise to him. He knew only too well the cost of fabrication, erection, maintenance and operating clean air equipment. There were basically two points of view to consider. The first was that of the 'anti pollution at any cost' lobby, and the second, that of the 'best practical means' or the 'value for money' approach. All desired that they should live in a clean atmosphere and avoid dust, dirt and pollution but there were very few who realised the cost of clean air or who were willing to pay the cost of the privilege of living in a clean environment. People did, of course, pay taxation and increased cost of purchases.

He well recalled that at the Clean Air Conference in Torquay some years ago, there was a lady who addressed the meeting and pleaded most eloquently that Dartmoor should be kept free from pollution. She was most emphatic that a proposed power station should not be built in the Plymouth area and that it should be built elsewhere, so that its effluent should not pollute her precious Dartmoor. There were, however, some people who considered that the confines of Dartmoor were undesirable. During question time he had asked the speaker if, in her cottage in the depths of Dartmoor she had light, refrigeration, cooker, deep freeze, hot water and even blankets operated by electricity. She replied that she had. He then asked her if she had all these amenties why she should not suffer from the effect of pollution which resulted from the generation of the large amounts of power which she used. Her reply was to the effect that the new Power Station should be located in the Midlands or the North where they were used to pollution anyway. She also added that the power transmission cables should be buried under ground so as not to cause visual pollution. She belonged to the 'anti pollution at any cost' lobby and had no idea of the commercial consequences.

He said that the 'I'm all right Jack' attitude was one side of the coin and on the other was the well known North Country expression "Where there's muck there's brass". This went back to the bad old days when coal was cheap and the chimney which belched forth dense black smoke indicated that the Mill was at work, goods were being produced, wages were being paid and a profit was being made. That energy was being wasted at a fantastic rate, that people were dying of bronchitis, did not matter, except possibl to the people who were dying.

He referred to Mr. Lowe's statement, concerned with steeply rising marginal costs of emission control, which might well mean that optimal environmental conditions may have already been achieved in some industries, or at least that the greatest environmental benefit might be generated by looking at some industries who had come under less scrutiny than others in recent years. This was a field which could well bear further investigation. Mr. Maule had indicated that fantastic sums of money had been spent by Industry to achieve the present high standard of clean air. This ran into thousands of millions of pounds. Mr. Lowe had said in his paper that the cost of control in a lead plant was £2 per ton at 95% efficiency, 5 times that sum at 99%. Was it worth the extra cost of £8 per ton to achieve an extra 4.9% of efficiency? Did the extra 4.9% have any marked effect on the quality of the air? Mr. Lowe had also indicated that in general, pollution control did not necessarily increase productivity. It was by producing goods that we existed as a nation and these must be produced at a saleable price in the World's markets.

He said Mr. Maule considered that the cost of anti-pollution measures had been worthwhile, but had stated however, "Whilst the economy can provide the money, the pressure to continue must succeed". Mr. Beaumont thought that the words "whilst the economy can provide the money" were the key to the situation. Could the economy provide the money? In general productivity was very low, taxation was high, unemployment stood at about 1½ million. The proportion of producers to users was 40 to 60 and there was a general lack of incentive both in management and on the shop floor. Could the economy provide the money? In his opinion the economy could and must provide as much money as it could afford.

He said that there should be clean air, not 100% clean, not 99.9% or even 99% clean, but air which was as clean as was practicable without bankrupting people or mortgaging the country to an overseas power forever.

Professor R.S. Scorer (Individual Member), said Mr. Lowe's contribution was a breath of fresh air, coming from an economist who had worked with industrialists and had tried to understand their problems in a practical way.

But it needed to be emphasised that, in our complex rule-making society, people were under great pressure to avoid responsibility because they could not understand things. For example in the new town of Telford the local authority and Development Corporation had required an aluminium refinery to instal filters on the flue gas from their furnaces to reduce emissions of sodium chloride to quite unnecessarily low levels. Untried equipment was used and a by-pass of the bag filters was not installed (although they had been advised to do so in case of difficulty because switching off a furnace is very costly). But the stringent restrictions were imposed partly because an application to build the refinery at Halesowen had been refused by that council because of a local campaign against the alleged pollution.

In the event the filters had become clogged and back pressure had caused fume laden emissions from the furnace doors and through roof vents, causing many complaints. When an application had been put before it for permission to build a zinc dip galvanising plant, the local authority committee had wanted again to impose stringent restrictions on the emissions, in that instance, of ammonium chloride, even using the confused argument that the previous technical advice on emissions, that no problem would arise, had been wrong because fumes at the aluminium refinery were a nuisance.

However, they had been persuaded that an important contributory cause to that problem had been the unnecessarily stringent restrictions imposed, requiring untried equipment to be used. In the course of the argument the Ministry of Agriculture and Fisheries had, on request, suggested a quite unnecessarily low limit for deposition of zinc compounds. This had not been backed up by any evidence, but, it seemed had been made low to cover the officer giving the advice. It was this disease of unwillingness to take responsibility that fortunately the Wrekin District Council did not succumb to a second time, but it was nevertheless rife, and arose because much advice, including on economics, was given in a theoretical way and not by people such as Mr. Lowe who worked with the problem as it really was.

Gas washing at Battersea and Bankside power stations had been examples of restrictions on emissions being imposed in a misguided manner.

An aspect of management of society missing from Mr. Lowe's considerations was the interests of posterity. He had mentioned "opportunity costs", but what about "opportunity benefits"? By this was meant using resources available now which would be scarce in future so as not to leave the next generation poorer than ourselves. There was a "glut" of oil at present because we had planned extravagant use of it upon ourselves in daily living, and it was time economists grappled with the problem of making fair provision for the future. Had they no means whereby posterity could effectively bid in today's market place, and influence our decisions by affecting our view of long term costs?

Finally, Professor Scorer turned to Mr. Lowe's reference to lead pollution. He had implied that simply because a significant proportion of lead consumed was used in petrol it must be the case that lead from traffic did correspondingly as much harm. It had to be remembered, however, that the body could tolerate a certain lead intake without harm, and that there had been no evidence in spite of 30-40 years of research that the intake from air containing car exhaust caused that level to be exceeded. Lead was a nasty substance, and it had been clear in discussions in the Clean Air Council, particularly those at which Professor Lawther had spoken, that a very careful watch was being kept on it. When that watch revealed no effects we should not take panic measures, and Mr. Lowe himself had shown a realisation that economic costs were a factor to be given due weight.

Mr. Lowe's style of argument was important because it helped to put things in proportion, which was in itself a great help to people to make responsible decisions.

Mr. J.B. Douglas (St. Helens M.B.C.), said he would like to illustrate a problem of fume emission from large furnaces such as those of the glass industry in St. Helens. These emissions had continuous, dense and stable white plumes, mainly of fine sulphate particulates which caused criticism due to their visual effect under varying weather conditions. They had no water vapour nor were they toxic and until the Department of the Environment set up the long promised Working Party on Fume Emissions there was no control standard available.

However, in recent years there had been a dramatic improvement in these emissions, rendering some virtually invisible, by converting the furnaces to gas firing instead of heavy fuel oil. This change was probably more effective than expensive pollution control equipment. The furnaces were large, ranging upto 1400 gallons/hour oil consumption, and fuel costs were a high proportion of the

manufacturing costs. They were not Alkali Registered processes.

Gas costs were normally slightly more than oil as more fuel was needed to provide the same amount of useful heat in the product because of heat transfer differences, but to offset this there were advantages of longer furnace life and lower pollution levels.

The problem now being faced was that on renewing contracts, gas prices were reported to have increased beyond a reasonable comparison with oil (25+ per cent in some cases). It was also reported that the British Gas Corporation could not or would not agree to suitable contracts of a sufficient period to justify the capital costs of converting furnaces to gas firing to cover the five year period between rebuilds. A case in point was of a £70 m for a new furnace which would operate from 1980 and would not be rebuilt until 1985 or so. A decision on fuel type was needed immediately - and the oil companies were prepared to negotiate on this basis.

Another company was converting back from gas to oil after several years without visible plumes and in the past 3 months these improvements had been lost. Both companies would have preferred to use gas. He remarked that they appeared to be going into the 1980's with the problems of the 1960's, having lost the improvements gain of the 1970's.

Whilst realising gas supplied must be controlled and paid for at a reasonable price, he wanted to ask Mr. Maule whether he had had similar problems with the steel furnaces which were converted to gas firing in Sheffield.

He wished the British Gas Corporation's representatives to pass on his concern and ask for consideration to be given to that pollution problem when negotiating contracts.

Industry should be prepared to pay more for those improvements and a higher cost for a cleaner fuel had to be related to alternative expensive means of fume control.

<u>Mr. T. Henry Turner</u> (Individual Member), referring to the two papers which had been given, said that they were obviously fundamentally important to the National Society of Clean Air, but neither of them gave both sides of the picture. What was the cost of not having clean air? So far as metals were concerned the First World War was nearly lost because condensers in ships corroded; that

was water pollution. The Second World War was nearly lost because boilers corroded, that was water pollution. So far as air pollution from Steam locomotives was concerned, rails laid in the open had lasted a life time but those in a tunnel under a ventilating shaft lasted a mere fifteen months.

The economist quite naturally told what people were spending to try to cure a nuisance, but nobody was able to tell - and this he said, was a challenge to Mr. Julian Lowe - what was the cost to humanity of not having clean air. Mr. Turner referred to city streets with horse traction and the risky job of road sweepers dodging the traffic to sweep up manure with a brush and pan and recalled the nuisance of flies that swarmed in those days. People had forgotten these things when they blamed road vehicle exhaust. They had forgotten what the conditions were, what it cost in every farm house to bring the smelly, smokey oil lamps to the kitchen table, clean the oil lamp shade and refill with oil etc. What had been the cost, when now 90+ percent of farms had electricity? What was the cost to human beings of not have clean air, so far as bronchitis was concerned? If this could not be put in the balance sheet, young planners might omit to bear it in mind.

Turning to the second paper, Mr. A.W.F. Maule was in the splendid position of following Mr. Batey and Mr. Law but if one went back to Mr. Law's time at the end of the last World War, Sheffield had been deliberately making smoke to try and hide itself from air raids. Unfortunately it was not too successful as Sheffield was badly hit. At that time there were no nationally standardised instruments for the measurement of air pollution. The British Standard instruments (of which our National Survey now used twelve hundred) only came into use a few years before London's 1952 smog. They knew something about what was in the smog but in Mr. Law's time Sheffield had no volumetric test apparatus.

Pages 12 and 13 at the end of Mr. Maule's paper gave tabulations of extraordinarily striking figures. The smoke decreased in Sheffield from 326 to 30, the sulphur dioxide decreased from 285 down to 71.

Tbe East Midland Division of the NSCA visited Sheffield on September 25, 1969 and were driven around for 12 miles without seeing any chimney smoke, except from the now disused Power Station down in the Don Valley to the east. There had been some stubble-burning away in the countryside to the West. It was an amazing change. In 1919 he had visited Sheffield with a party of

students and from the top of the Walker and Hall Building, they could not see green grass anywhere. The smoke and grime had remained until about 1950. From then the surrounding green fields were once more seen. As a result of the clean air in Sheffield not only did one see greenery inside the City and on the surrounding hills but people had a fascinating view of the lights of Sheffield from the hilly suburbs. He congratulated the author of that second paper on the Clean Air achievement in Sheffield. He had told them a story that required imitating by those who would take into consideration what not having clean air cost.

Mr. Turner asked the delegates to picture a diagram vertically, the nuisance whatever it might be, air pollution, water pollution etc.: and horizontally, the cost of reducing the nuisance. It was possible to decrease the nuisance 30-60 percent at bearable cost, and that again had to be maintained. From the Society's point of view it was essential to maintain the decreases in air pollution such as those achieved in Sheffield during the past 20 years.

Mr. P. Draper (Individual Member) said the papers had been very informative. The emotive subject of lead had been mentioned by Mr. Lowe and Professor Scorer which had largely put the matter in order, but there were further points that Professor Scorer had not made. He had understood from the speaker that under 2% of the lead in the air was supposed to come from factories and that implied that the rest, more or less, came from vehicle pollution. But that was not fact. There was a factual Government Report on the subject, "Lead in the Environment and its significance to Man" DoE CUEP, HMSO 1974.

The report was entirely on the subject of lead in the atmosphere and it stated that most of the lead ingested into human systems, was taken in with food and drink. He felt that was an irrefutable statement. The paper had also stated that there was no evidence whatever that lead from petrol vehicles was causing any harm to human beings. Nevertheless, the Government had decided that they would lower the maximum allowable content of lead in petrol at the oil companies refineries, where petrol was manufactured. They had said they would do this although there was no real reason for doing so, except to keep lead levels down in a general way. This could be done because the petrol companies and the motor manufacturers had agreed to it. The reason that it could be done and that companies did not mind, was that lead was already well

below the new lower maximum level, so it did not cost them anything more.

He said it was a very emotive subject. Only two or three days before Mr. Draper had seen an article in the Daily Telegraph which reported a recent decline in lung cancer, which it had said was obviously due to the Government lowering of the maximum allowable lead in petrol. The fact that the lead was not reduced anyhow because it was already low, seemed to have been missed by that Author so people must not get too emotive on the subject of lead from petrol.

Referring briefly to Mr. Maule's paper, he said it was a most remarkable paper of really wonderfully practical achievements, which had given him enormous pleasure. The Society knew his Predecessor, Mr. Batey very well and regarded him with high esteem. He had also fully backed the Society. Those two gentlemen had achieved something really spectacular in Sheffield. There were other places where steel was, or used to be, manufactured, where they might adopt the same principles with beneficial effects. He thought it was really very wonderful work and congratulated Mr Maule on his presentation.

Mr. D.H. Evans (Coventry M.D.C.) said he was concerned with the problems in the re-activation of the smoke control programme in local authorities. There was a competition for resources in local authority budgets and the bias was to the education departments and social services. There was little political dividend to elected members in smoke control because of the absence of public pressure.

He challenged the morality of local authorities requiring expenditure in the private sector when they themselves were not expending money in the public sector on smoke control. According to Mr. Maule's paper total smoke control of Sheffield was secured by the expenditure of £3½ million. Mr. Maule had gone on to enumerate the millions of pounds spent by the industrial section to meet clean air requirements.

The most recent smoke controlled area in Coventry had revealed that only a quarter of appliances required to be adapted and of this quarter, a half ranked for 100% grants because of the low incomes of the tenants. It was clear, therefore, that most people had adapted their heating arrangements without regard to smoke control and in general had opted for convenience fuels.

A recent document of the Government regarding concern for the aged,

pointed out that one of the problems met was that of hypothermia amongst the aged population, and he submitted that one of the major factors in this was the burning of solid fuel: often old people were found huddled in front of a fire composed of two or three coals burning pallidly. There was also the question of rising to a cold house to light fires. It seemed, therefore, that the remaining houses were preponderantly those of the poor and of the aged, and that smoke control should go on until the target of 100% was met.

Mr. H.I. Fuller (Esso Petroleum Co. Ltd.) addressed a question to Mr. Lowe, who he thought had presented a very interesting paper on the subject of the economics of pollution control. Clearly there were many factors involved, and many were not quantifiable. Mr. Lowe had concentrated a great deal on those industries, mainly the non-ferrous metal industries, where the arisings from pollution control could lead to valuable materials for recycling and recovery. He wondered, however, if he had considered cases where the materials which arose from the trapping of pollutants were worthless as for example with electro-static precipitated dust which was produced by Power Stations in large quantities. This had to be disposed of by lorries and put into a hole in the ground which was not an easy matter and certainly not a positive benefit. He also referred to scrubbing flue gases to get rid of sulphur dioxide. One of the favoured methods in the United States produced a rather unpleasant slurry in such vast quantities that a 2000 MW power station would cover 10 acres of land 40 feet deep each year. That was a lot of land.

Referring to energy costs he said that when considering reducing the sulphur content of fuel oil for electricity generation, the Electricity Board had estimated it would add 20 to 30% to people's electricity bills. He asked what extra risk the additional cost would bring to the elderly, many of whom already died of hypothermia every Winter.

Professor Lawther, writing in 'New Scientist' in April 1978, had made it clear, he felt, that the effects of urban pollution on health were now insignificant compared with the effects of cold weather and infections. There was an episode of high pollution in London in December 1976, when sulphur dioxide levels went up to six times the normal daily value. There was no effect whatsoever upon health statistics. Yet a few weeks earlier when there had been a cold snap, the number of excess deaths (the figure often quoted for the 1952 and '56 smogs) increased quite substantially.

He said Professor Lawther might be right. The air might be clean enough with regard to smoke and sulphur dioxide - although we would certainly agree that the present high standards should not be relaxed. He believed that there should be much more control in specific places, than over the broad sweep of urban pollution everywhere.

Mr. H.R. Sutcliffe (Nailsea Engineering Co. Ltd.), said he was not quite certain whether Mr. Lowe was right or not. He had been growing roses for thirty years, with most of that time spent in industrial Lancashire. Having moved to Kendal, his roses were dying of Black Spot, whereas the SO_2 in the air in Lancashire had kept them quite free. There was a great benefit in Kendal where the air was reasonably clear - he could at least see what his roses were dying of!

He wanted to make a serious point in connection with Mr. Lowe's concern about the problems of small businesses in selecting dust collection or air cleaning equipment, where experience has shown that installed equipments did not meet the requirements laid down or the claims made. He said that firms should not go to the supermarket and buy something 'off the shelf'. They should go to people who would size up the job and install equipment to suit their particular needs. It would certainly cost them a lot of money if they installed a plant which did not work satisfactorily.

He commented upon the excellence of Mr. Maule's paper, and in particular, about the Stocksbridge and other B.S.C. plants. The cost of equipment to deal with the fugitive emissions was high because they had to move colossal amounts of air in order to remove very small amounts of particulate. The power costs were high for the same reason and were a continuing charge.

Mr. Fuller had referred to the problems of disposal of dust collected in power stations. Large quantities of these dusts were used in making lightweight aggregates. He had seen buildings in London constructed from these and felt perhaps there were some benefits from power stations, apart from the amount of electricity they generated.

Professor Scorer had made some observation about a problem created by ammonium chloride in a galvanising process. So far as galvanising was concerned, the zinc oxide fume might not be disastrous to health and, in fact, the recovered sludge was a very useful by-product which was sold to manufacturing chemists at a high price. The question was whether one would like to have the ammonium

chloride on one's garden to make the grass grow, in one's lungs or, upon one's motor car which would eventually disintegrate with corrosion.

Julian Lowe, replying to the discussion said there were several points which he wanted to bring up following the interesting comments of the discussants. He dealt first with the question of lead, mentioned by several speakers, and said that recent DoE Reports had indeed suggested that lead was frequently ingested via food as well as being inhaled through the air. However, it was still true that lead levels at heavy traffic locations were still higher than where there was less traffic and often higher than near lead works. The ambiguity in British and American research was not whether lead in the atmosphere was correllated with traffic but whether it got into the body through inhalation or ingestion.

The example of lead had been used because he had wanted to point to an interesting problem of environmental control. There were a lot of things that hurt people, there were a lot of things that caused a nuisance, but the impression was that what to tackle first was sometimes based, not on scientific fact and evidence but on a reaction to a particular problem that might have been generated by the media at that time. As to whether or not lead was in fact such a case he thought there was certainly some room for argument. Certainly the Americans had decided on much greater control of emissions from motor cars and he suspected that this was on the basis of very important evidence that had been turned up by the EPA.

The second point he wished to address himself to was that perhaps there had been a misunderstanding by some of the discussants who had suggested that there was a choice between no control or control. The point he was trying to bring out in his paper, and a point which Mr. Turner had emphasised, was that they had to make a value judgement irrespective of the common property problem, as to how much control was good for people. In some areas and in some aspects of environmental control, it might pay society to switch its resources and switch its efforts to some alternative areas of environmental control. He was not disputing that control was good for people, but he was wondering whether or not they had the information for policy makers to make the decision on where further control should be introduced.

The final point he wished to make referred to an issue brought up by two of the speakers, Mr. Beaumont and Professor Scorer and concerned what he called cross media transfer of pollution. He thought there was a danger, particularly when there were several

control agencies, the Alkali Inspectorate, the Water Authorities, sometimes the local authorities and sometimes internally, within the factory, the Health and Safety Executive. Problems arose in that cleaning up the air could lead to serious problems in other parts of the environment. He was interested to hear Professor Scorer's comments on the secondary aluminium industry, where there had been an attempt to clean up one environmental problem and it had in fact lead to another one. He had come across an interesting similar case in the copper and brass industry, where to reduce the black smoke emission from brass foundries, oil drying equipment had been installed in some factories. In some cases the use the oil drying equipment, whilst it had got rid of the oil from the swarf that was fed into the foundry, and thus reduced black smoke, actually increased some lead emissions to the air.

He thought the problem of cross media transfers, whether it was cross media within one media, from one part of the air to another part of the air, whether it was cross media from the air to the watercourse or from the air to solid environments and eventually the watercourse, was a potentially important one and one on which a great deal more research must be done.

Mr. A.W.F. Maule, replying to discussion, said he was afraid he was unable to help Mr. Douglas very much. He had asked if he had come across similar problems in industry and in fact he had not. Many companies in Sheffield had converted from oil to gas and as far as he knew there had been no problem whatever with regard to the tariff.

He sympathised with Mr. Evans of Coventry. Fortunately his City Council were in favour of completing their smoke control programme. When reorganisation took place, like many other authorities in the Country, they had added areas that came in; some had started smoke control but had not finished it. Their Council had encouraged them to carry on. In fact, one of the areas had come into operation in 1976. They had another coming into operation in October 1978 and they had just had a third confirmed. They only had one more to do and the survey was going ahead. He agreed with Mr. Evans that smoke control ought to continue.

Referring to Mr. Turner's point, he said that although he was not in Sheffield at the time, certainly in the Second World War, smoke abatement was abandoned and factories and steel works were in fact asked to make smoke to try and camouflage the City from enemy aircraft. As Mr. Turner had rightly said, it had not worked very well because they were bombed just the same.

With regard to Mr. Turner and Mr. Draper who had both commented on the wonderful change which had taken place in Sheffield, his answer to them was that the Clean Air Act had worked wonders. In fact, he would stick his neck out and say that the Act was the greatest breakthrough in the drive for clean air throughout the country.

Finally, referring to Mr. Sutcliffe's point about the high cost of scrubbing flue gases, he said it was certainly true that the operation was very expensive, a point which he had noted both in his address and in his paper. They and the Alkali Inspectorate had had so many complaints about fume emissions from the roof of melting shops, even with the provision of scrubbers and precipitators, especially during oxygen lancing and pouring and tapping. The public would not accept it, so it had to be cleaned up. With the provision of roof extraction plants it had been cleaned up and worked very well and efficiently.

INDEX TO SPEAKERS

NATIONAL SOCIETY FOR CLEAN AIR

45th ANNUAL CONFERENCE
2-5 OCTOBER 1978
BRIGHTON

LOW ENERGY STRATEGIES FOR THE UK

by

Gerald Leach,
Director, IIED Energy Project;
in collaboration with
Gerald Foley, Chris Lewis,
Frederic Romig, and Ariane van Buren

136 North Street
Brighton BN1 1RG
England

We have been working for two years on a detailed energy scenario for the UK and have come to some surprising conclusions. We think that this country could have 50 years of prosperous material growth and yet use less fuel than we do today. More specifically, if G.D.P. increases by three times in real terms over the next 50 years there could be zero energy growth. If G.D.P. only doubles, the total use of fuel could drop by 25%.

Now this conclusion may be surprising to many people. It upsets the conventional wisdom that a low energy future must be bleak and that energy use is strongly linked to economic growth. It also challenges the technical optimists of the nuclear and other supply industries, that they can bridge large energy gaps, by suggesting that they are the true pessimists. There are many simpler and safer technologies and strong saturation effects in the use of energy that could make those hypothetical energy gaps disappear. Our conclusions also challenge the social optimists who believe that the coming energy crisis can only be solved by fundamental changes in attitudes and practices; whether nobly by turning from acquisitiveness to altruism; or austerely, by wearing pull-overs and bycycling everywhere; or technically by covering the place with windmills and solar collectors and fuel farms. Those sort of changes are not necessary, though some of them may be desirable. If society did move in these broad directions, energy use would probably be even lower than we are forecasting.

Before I describe what we have been doing and what we have found out let me quickly explain what we have not beendoing, what we have tried to avoid.

My first example is an electricity forecast that appeared within the last 10 months, showing the capacity of power plants going up from 85 GW in 1980 to about 250 GW in 2030. We keep seeing fore-casts like this, which just extrapolate past trends up a hopeful growth curve. Nothing is said in the forecast about exactly where and why that electricity will be used and what sort of market changes will be needed to get that kind of electricity growth.

Nor have we been trying to do the kind of forecast that is done by the Department of Energy. Basically, what the Department of Energy have been doing is to look at past trends - that is, 1950 - 1976 - and relate energy use to income or to the output of industry. They then extrapolate that forward and get a series of curves. One shows what will happen in future, assuming 1950 technologies. A lower curve shows what would happen on 1976 technologies. The next lower curve assumes some technical advance

between now and 2000. In the final curve - the actual forecast - there is another drop due to 'conservation' - a matter of 15% in 2025. Now, one of our arguments is why 15%? Why not less? Why not more? If you comb through the Department of Energy forecast you can never come up with a good answer to this question. Nothing is made explicit. No policy assumptions are put behind those figures. Indeed, one of the best things about the Department of Energy forecasts is that they are falling year by year, as fast as oil reserves are rising.

Another approach that we have been questioning is the fundamental notion that energy use is intrinsically linked with G.D.P. Even before the 1973/74 oil crisis this idea was beginning to crumble, but in the last 5-6 years it has been all but shattered by people who have been looking carefully at energy. They have shown that the relationships between energy and G.D.P. to be found in different countries over long periods of time have no intrinsic validity beyond that of coincidence. However, the accompanying mythology that energy equals wealth has been slow to die.

Let me give some examples of what happened in the 1950s and 1960s in the UK, when we did indeed have quite a stable relationship between energy growth and G.D.P. Over that time, two-thirds of the growth in final energy usage was accounted for by road transport during a period when car traffic multiplied 6-fold. Electricity growth was rapid until it began to slow in the late 1960s. The number of households was increasing rapidly - an increase that cannot continue and must soon flatten off. The ownership of electricity-intensive appliances such as refrigerators, washing machines, T.V.'s etc., was increasing very rapidly. Although it has not yet reached saturation, the trends are beginning to curve over. Heating systems improved very considerably so that many people, but not all, have reached comfortable standards of warmth which they will not want to improve. You can after all get too hot indoors. So there are obviously powerful saturation effects coming up, about which the kind of forecast that extrapolates past energy and economic relationships tells us nothing.

But to show just how unsound is the basic idea of linking energy and economic growth, consider the non-manufacturing sector of the economy. People working in offices, schools, hospitals and so on, generate over half the gross domestic product but use only 12% or so of total energy. That is mostly for heating and lighting buildings, not for creating G.D.P. itself. So energy consumption could easily fall while G.D.P. output, which depends on human skills, goes on rising.

A fourth aspect of energy we wanted to look at were a number of surprise effects that are often missed in forecasts. Free heat gains in buildings are a good example. About half the energy used in the UK is for heating buildings. Now imagine a typical house that is losing 50 units of heat through its fabric. About 15 units of heat is supplied by lights, people, electrical equipment, cookers and hot water, so you have to provide 35 units of heat to keep warm. Now if you insulate that house quite well and bring the heat loss down to 60% of what you started with, you still have the same free heat gain. Consequently, you need provide only 15 units of energy or 43% of what you began with. There is a much bigger drop in heating than you might at first think. This sort of effect is one reason why we believe that you have to use a physical model in forecasting, not an economic one.

Now it is about time that I said what we did do. We began by saying, in a sense "forget the past, start with 1976 as a base year". To do this we made a very detailed breakdown of how energy is actually used in our society. To give one or two examples, we broke industry down into eight sectors; seven different kinds of fuel or heat; and thirteen end use purposes (direct process heat by four different temperatures, indirect process heat by four temperatures of final use; space and water heating, electro-chemical processes; lights, other electricity and other uses of fuels such as off-road vehicles). We were lucky to get these data from the National Industrial Fuel Efficiency Service and the Energy Technology Support Unit and it produced a number of surprises. For example, in the engineering sector as much as 36% of energy is used for space and water heating; in iron and steel, only 2%. In housing we started off with 4 different types of housing - existing and still-to-be-built houses and flats - and we took space heating and water heating, cooking, lights and appliances separately. Allowing for all sectors, we had 140 basic activities in which energy is used. When you include the different fuels and appliances that meet those needs we had about 480 basic items of energy use. From this work, we found that essential uses of electricity come to only 8.1% of the total uses of energy, while 60% of energy is for heat, 21% for transport and 11% for feedstocks, bitumen, lubricating oil and ships bunkers.

We next chose a large range of basic activities that measure material standards and forecast them: factors such as vehicle traffic, levels of temperature inside houses, the number and size of houses, floor space for offices, and so on. To do this, we had to assume a growth of G.D.P. We have two projections - a high and a low. In the High case there is a trebling of G.D.P.

from 1976-2025, and in the Low a doubling. Interestingly, these growths are very close to the low and high assumptions of the current Department of Energy forecast. Equally important, are the assumptions about particular rises in material standards. Most families come to own freezers, dishwashers, clothes driers and so on. Car ownership grows rapidly so that by 2000 some 72-75% of householders will own cars. At present the figure is 58%. Air traffic grows by 2½-3 times. Industrial output increases by 1½-2 times, and so on. We have not supposed a future of material austerity.

Having produced these activity growths, we then ask about conservation. We used three guidelines. One was to look at the ferment of technical response that has occurred since the oil crisis of 73/74: looking at the technical literature, canvassing experts, and having a series of one day sessions where we put up our assumptions and the experts knocked us down. We did that in every sector, working closely with the Energy Technology Support Unit, at Harwell, and members of the Energy Thrift Committee and the Energy Audit team, particularly on the industrial sector. We assumed higher fuel prices, basically a 2-3 fold increase in oil prices in real terms, but the exact figure is not critical to the model. The forecast is not driven by higher prices; fuel prices are used to test whether conservation is cost effective.

Another input to the forecast was an assumption that the present pace of government policy, and awareness among professional groups like the NSCA, continues unabated. The professions are very rapidly becoming more aware of the rational use of energy, and we simply assume that this kind of thing keeps up: it does not have to increase much but at least there is no drop in the level of interest in energy conservation.

These three pressures of the technical response, higher fuel prices and policy awareness on conservation, have already held energy demand flat for the last seven years. Demand in 1977 was no higher than it was in 1970 despite a 10% rise in G.D.P. We are simply saying that that can continue.

I had better mention conservation measures we have assumed - though obviously I cannot give a complete list. In industry the fuel consumption per £ of output falls by the year 2010 by 22-35% depending on the sector. That is an average of only .6 - .9% per year and in some cases is slower than past trends towards less energy-intensive manufacture. In reviewing our work we feel that we have not been nearly as bold in the industry sector as we might

have been. In housing, we assumed that it takes 35 years before all existing dwellings have loft and cavity wall insulation, if they have lofts, and cavity walls. If they have solid walls, nothing happens. On new dwellings the building regulations are tightened successively over 1980-1990. Following discussions with the Department of Environment and the R.I.B.A., as to what they would expect to happen, heat losses are reduced in 1990 to 50% of the present standards, which is well within the limits of the current types of construction within this country. Many houses in the UK have already been built to these 1990 standards with costs of only a few % above conventional dwellings. With heating equipment we have assumed only that modern best practice devices are installed in new dwellings and replace those in the existing houses as these wear out. Electric and gas heat pumps, which are expected to be in mass production during the early 1980s from several groups, are introduced gradually to provide a combined 15% of the space heating market by the year 2000. The assumptions about commercial and institutional buildings are very similar. In transport our conservation assumptions are generally more moderate than those of the Department of Energy. For example, the current Department of Energy forecast assumes that the specific fuel consumption of cars and vans will drop by 40% by the year 2000. We did a lot of work with the motor industry and came up with equivalent figures of 34% for cars, 26% for vans, and only 10% for heavy lorries. Electric cars, vans and buses we have assumed will be introduced only after 2000, using the sodium-sulphur battery. This is being developed quite rapidly, but we have left a 20 year gap between the present prototype stage and the time when they enter the car market and another 10 year gap before they penetrate to quite high levels. We also assume some fuel switching, especially from heating oil to coal.

Let me now present our results. For the High case where G.D.P. trebles there is virtually zero growth in primary fuel demand from 1976 to 2025. In the Low case where G.D.P. doubles, primary fuels drop by 25% over the period. These remarkable forecasts are not achieved by hugely optimistic assumptions about solar, wind, wave or other renewable energy sources. In 2000 we have only 4 - 5 million tons of coal equivalent coming from these sources. The current Department of Energy forecasts have 10 million tonnes, over twice as much. In 2025 our figures are 24-30 million tonnes, which is less than the 30-40 million tonnes that the Department thinks might be possibly by 2000 or an optimistic guess. We have deliberately been extremely conservative about solving the energy problem through the massive introduction of renewable sources, not because they are unattractive, not because they are not going to be developed, but because their economics and in some cases their

technologies are not yet proved and we did not want to be shown to be trying to solve the problem by wild optimism in that direction.

An important aspect of these projections is the way fuel demand keeps steady or continues to decline well beyond 2000, despite rising material standards. This is because it takes 20-30 years for some major structural changes - like the housing and industrial stock - and for major conservation assumptions to make their mark.

Although it is ridiculous to forecast 50 years ahead, it is possibly just as silly to stop short at 2000 with a rising energy trend because then you may miss these long term effects which, on the whole, tend to bring energy use down.

Let me now describe what a remarkable effect these forecasts have on Britain's capacity to provide its own fuels. With coal, we are far below the Plan for Coal production target. With oil, demand has dropped very rapidly over the last few years. If North Sea reserves are the presently estimated 6,000 million tonnes of coal equivalent, we get an 'oil gap' opening up around 2010. However, we get a very small gap if reserves are at the upper end of the present range of reserve estimates. In the Low case, we get a very small gap only on the middle estimate of 6,000 mtce reserves. The worst gap in 2025 (High case, 6,000 mtce reserves) is the most serious problem in our forecast but is only equivalent to half the recent level of oil imports: about 40-50 million tonnes of oil a year. There should still be a lot of oil in world trade even in 2025, and the oil companies are enthusiastic - as indeed are we - about the chances of fuels from plants grown in the tropical belts of the world. Biomass production of alcohol and methanol could be quite substantial by that time, so that oil gap need not be a major problem. With natural gas, we get a small supply-demand gap only in the last 10 years of the 50 year period, and that is on the middle estimate of reserves. On the Department of Energy's upper estimate, there is a surplus to well beyond 2025. With nuclear power, there is a rise from the present level to 1990 because of the plant that is now in the pipeline. Thereafter, we have assumed a construction rate of 3 gigawatts - or maybe two power stations - every decade: a "tick over" level so that the industry is kept alive in case one needs it later, perhaps for climatic reasons if the world has to cut down the burning of fossils fuels. The main reason why we have not put in more nuclear is simply that if we did, the use of coal in power stations would drop catastrophically. If we had the Department of Energy's 2000 forecast for nuclear, our coal burn for electricity generation would be zero and total coal production

would have to be halved. That would present some awkward social problems. In our forecast to 2000 only 25-30 gigawatts of generating plant of all kinds need be built between now and 2000, compared to 83 gigawatts in the Department of Energy projections. At current costs of power stations the saving in investment is £26-30 billion pounds, or well over £1 billion a year. We would be surprised if that sum does not greatly exceed the cost of all the energy conservation measures assumed for all of our sectors.

Is such a future really credible? We believe this is the wrong question. If you look at our assumptions when they are published I do not think you will find them extreme. But the question of credibility misses the real point. Within limits almost any future is possible and - again within limits - there are no laws about the future of decision-making. What does limit our decisions about the future is the kind of future that perceived wisdom tells us will occur. Official forecasts set official policies, because official forecasts implicitly assume official policy. So those policies are carried through and the forecaster, give or take an error of 50%, is proved right. There are vicious circles here which we believe must be broken. They must be broken by exposing a much wider range of plausible futures and, as we have tried to do, by making every step in the forecast, every assumption, crystal clear and explicit, so that others can test it and say "you are wrong there, you must do differently there". By doing this one also makes the policy implications crystal clear.

NATIONAL SOCIETY FOR CLEAN AIR

46TH ANNUAL CONFERENCE
15-18 OCTOBER 1979
SCARBOROUGH

WEATHER AND AIR POLLUTION

PART 1
PRE-PRINTS OF PAPERS

136 NORTH STREET
BRIGHTON BN1 1RG ENGLAND

46th ANNUAL CONFERENCE
SCARBOROUGH, 15th - 18th October 1979

THE WEATHER
Jack Scott

THE ACCURACY OF FORECASTING POLLUTION
Dr. F.B. Smith

A VISUAL PRESENTATION OF THE EFFECTS OF WEATHER ON POLLUTION
Professor R.S. Scorer

METEOROLOGY AND AIR POLLUTION
Dr. D.J. Moore

GENERAL METHODS OF MEASUREMENT AND MONITORING
Dr. A.W.C. Keddie

ADVANCED METHODS OF MONITORING AND MEASUREMENT
Dr. R.H. Varey and David Green

FACTORS AFFECTING ENVIRONMENTAL SOUND PROPAGATION
Harjodh Gill and Professor J.B. Large

THE EFFECTS OF WEATHER ON NOISE MEASUREMENT AND ASSESSMENT
Peter Sutton

THE ACCURACY, INTERPRETATION AND USE OF RESULTS OBTAINED FROM MONITORING AND MEASUREMENT OF AIR POLLUTANTS
Dr. M.J.R. Schwar

THE EFFECTS OF POLLUTION ON CLIMATE
Dr. B.J. Hoskins

NATIONAL SOCIETY FOR CLEAN AIR

46th ANNUAL CONFERENCE
15-18 OCTOBER 1979
SCARBOROUGH

THE WEATHER

by

Jack Scott
Meteorological Office

National Society for Clean Air
136 North Street
Brighton BN1 1RG
England

Although there has been interest in the weather throughout the ages, a proper scientific understanding of it has only begun in the last one hundred and fifty years. Very slow progress was made initially, mostly because no measurements could be taken on a large scale in the upper atmosphere. Progress in this respect was made after the advent of the aeroplane, and improvements in research and technique have continued as higher and higher probes have been accomplished, first through Radiosonde and latterly through Satellites. The use of Computers has improved longer range forecasting.

The basis of all weather is the heat energy generated by the sun. Therefore the main centre of the weather engine is around the Equatorial area, where most of the heat energy is received and re-generated. The first thing that most of us learn at school about the weather is that warm air rises at the Equator and travels outwards towards the Poles, then cools and sinks and eventually returns. We call this cycle the General Circulation. Paradoxically, this is the feature we probably know least about in quantifiable terms, mostly because the problem is on such a vast scale, and before the arrival of the Computer, any mathematical calculations involved were too big to be tackled. With the Computer, however, and with other modern aids, principally Satellites, we are beginning to be able to take the measurements and perform the calculations which will eventually lead to a better understanding of the General Circulation. We do know, however, that the General Circulation creates wind. Warm air, in rising leaves a partial vacuum on the surface, and neighbouring surface air moves in to fill the vacuum. This air is really the wind, for wind is merely air moving from one place to another. Wind is one of the most important features of the weather, because it is the "heat carrier"; if it were not for the wind, the Poles would get colder and colder and the Equatorial areas hotter and hotter and there would be only locally generated weather. The General Circulation causes the relatively high and low pressure areas too. For instance, as the warm air on the Equator rises, so the surface pressure there lowers, and later, when elsewhere the air starts to sink, surface pressure at that point becomes higher. This is initially how the patterns on television and newspaper weather charts are formed.

In high pressure there is comparatively little movement of the air. The air in that area therefore takes on the characteristics of its surroundings. For instance, over the sea near the Equator it will become warm and moist. Similarly, an air mass forming at a higher latitude would be cold. So if these two masses of air were to meet, the warmer air would tend to rise over the colder air, its

moisture condensing into clouds, and a front would form. The sequence would continue with a wave forming on the front and continuing to grow until a depression appeared. These frontal depressions are the features which normally figure most in our temperate zone weather.

The foregoing is briefly how we arrive at a weather chart from basic principles. In practice a weather chart is drawn from a set of weather observations which is collected through international co-operation. There has been an international governing body since 1873; it is now called The World Meteorological Organization. One of the main rules of this Organization has always been that weather information read at specific times will be exchanged at regular intervals every three, six, or twelve hours. These weather data can be set on a map which then gives an instantaneous account of the weather, say, over a hemisphere at a particular time. The map is analysed, the various readings showing where high pressure, low pressure, and any fronts exist. It follows that a succession of such maps will show the movement and development of these features and will also suggest where they will be on the next map, as yet unplotted. From similar maps, based on temperature and wind distribution in the upper atmosphere, these future movements can be verified, and nowadays, using a Computer programmed to the Laws of Motion and Thermodynamics, we are able to project weather maps for several days ahead. By this method, we can now forecast for up to six or seven days ahead, and this extension in range of forecasting is one of the greatest improvements made in the last twenty to thirty years. There has been not as much improvement in the same period in the very short range forecast, over the first six to twelve hours, but now there is a project aimed at this problem. A Research Team, using RADAR and Weather Satellite images is trying to discover and improve techniques leading to a more accurate forecast in this shorter range.

Forecasting in other ranges of time can of course also be said to be in the research stage, for we are learning all the time and improvements will continue to be made. International co-operation is now being seen more and more in this area. Weather Satellites and Computers are being shared; a vast international experiment was conducted over an area of ocean off West Africa a few years ago and this year sees the First Global Experiment. The problems involved in forecasting the weather are being tackled very seriously indeed.

NATIONAL SOCIETY FOR CLEAN AIR

46th ANNUAL CONFERENCE
15–18 OCTOBER 1979
SCARBOROUGH

THE ACCURACY OF FORECASTING POLLUTION

by

Dr. F.B. Smith,
Meteorological Office

National Society for Clean Air
136 North Street
Brighton BN1 1RG
England

Airborne pollutants are worthy of study because of their effects on health, amenity, buildings, animals or vegetation. Sometimes it is the concentration in the air that is important, and how this concentration varies in time. In other cases it is the actual amount of the pollutant which gets deposited per unit surface area of the underlying ground by one means or another. With some pollutants both are important.

In every case the nature of the atmosphere and its ability to carry the pollutant, to dilute it and disperse it, is of vital concern.

To take an example, domestic central heating systems may emit sulphur dioxide, one of the commonest of all air pollutants. The householders will adjust the system to maintain a comfortable temperature inside the home against heat losses caused by conduction and ventilation losses. The rate of emission will therefore probably depend on the exterior wind speed and air temperature.

The 'plume' coming out of the chimney or vent will be warm and will rise. In light winds the rise may be many metres. In stronger gusty winds, the plume will get bent over quickly and may get caught up in the turbulent eddies in the lee of the house and brought down to ground very rapidly. In partial compensation the emission is injected into a longer run of wind in strong winds than in light winds, tending towards overall lower concentrations.

The sulphur dioxide is carried away downwind and the areas affected clearly depend principally on wind direction. At very short range wind direction may be treated as spatially constant. At somewhat longer range allowance might have to be made of the effect on the airflow of such things as the urban heat-island, hills and valleys. Coastal effects (e.g. sea breezes) and large clouds which generate their own meso-scale circulations.

Some of the sulphur dioxide will be absorbed by the ground and the vegetation. Some of the remainder will be oxidised to sulphate and the rate at which this occurs depends principally on the relative humidity of the air, although other meteorological factors may be important. Sulphate is absorbed by the surface much more slowly and can often travel through the atmosphere many hundreds of kilometres. Much of the sulphate is only removed when it is drawn into a rain area and washed out, perhaps at great distances from its original source.

One can see from this briefly considered example, the daunting range of meteorological and environmental parameters that may be

important.

Except in very complex cases, the ground-level concentration of a pollutant sampled in the plume over a few minutes and at downwind distances of up to a few kilometres can usually be estimated to within a factor of about 2, compared with actual measured values, provided the emission rate is known. The accuracy improves as the period over which the plume is sampled is increased. The cause of these errors is not principally due to the inadequacies of the models we use, although of course these play some part, but is largely due to the inherent variability within an otherwise uniform air flow. At large distances downwind the accuracy becomes gradually less. The reason for this is that errors in trajectories are typically cumulative, especially on the scale of weather systems, like depressions and anticyclones.

In certain rather important instances it may be essential, or maybe just simply desirable, to forecast concentration levels ahead of time. The following examples illustrate this point. The first example refers to certain cities round the world where concentration levels of smoke and sulphur dioxide occasionally reach such levels as to present a definite hazard to inhabitants with chest and heart complaints. A concentration forecasting scheme then becomes highly desirable in order to advise the public of forthcoming levels, to provide a basis for possible emission control and to prepare hospitals for possible influxes of patients.

The second example refers to the accidental release of some toxic, explosive or radioactive material from an industrial plant. Often the release is not instantaneous but is spread over many hours. During this time the wind field (and other meteorological parameters) may change very significantly. In order to dispose whatever emergency services are available to the best possible advantage of the public, some estimate of these changes is required as soon as possible after the accident is appreciated.

The third example concerns the long range transport of industrial air pollutants and the depositions experienced in sensitive areas, maybe one or more thousand kilometres from the source regions. The deterioration in the fauna-supporting quality of many Scandinavian lakes is an example of this situation. Acid rain appears to be a major contributing factor to the decline in lake pH values and a consequential decline in the fish populations there. In theory it would be possible to alleviate this problem by forecasting air movements to Scandinavia two or three days in advance and applying fuel switching to more expensive low-sulphur fuels at appropriate

large industrial plants where this would be feasible. In practice this is a costly solution and in any case such forecasting is obviously subject to error.

The object of this paper is to look at some of these forecasting situations and to attempt to assess the accuracy with which the relevant meteorological parameters can be forecast and the consequences this has on the accuracy of concentration predictions.

Let us briefly summarise the situation here. Detailed figures will be given in the full paper.

1. URBAN POLLUTION

The Meteorological Office sulphur dioxide forecasting model for London has been in operation during the winter months since 1971, and provides a useful guide to trends in concentration. Twenty four hour average concentrations are forecast each day for the following day. Correlations between predicted and actual concentrations are typically about 0.7 to 0.75. The errors in forecasting the meteorological parameters, although relatively small, nevertheless are one of the principal sources of error in the model. Two of these parameters are the expected minimum temperature (root mean square (r.m.s.) error 2°C) and the number of hours when the mean wind falls below 5 knots (r.m.s. error 4 hours). In combination these result in a r.m.s. error of concentration of about 50 $\mu g\ m^{-3}$ (compared with a winter mean SO_2 concentration of about 200 $\mu g\ m^{-3}$).

Wind direction is relatively unimportant in most cities unless one or two very strong sources dominate the concentration pattern.

2. ACCIDENTAL RELEASES OF HAZARDOUS POLLUTANTS

The principal error here arised from changes in wind direction. An analysis of time sequencies of trajectories over a range 1 to 30 km will be presented based on hourly surface wind observations. These variations will be compared with corresponding changes in geostrophic wind direction deduced from the normal synoptic network of observing stations.

Other errorsarise from variations in atmospheric stability, especially in the lower layers, and in wind speed. More serious accidents might potentially affect areas out to some

1000 km or more. A study of "trajectory swinging" in time out to these ranges will be presented, and the results will include the effects of release period on the magnitude of the swinging.

3. EMISSION CONTROL IN THE LONG RANGE TRANSPORT OF POLLUTION PROBLEM

An analysis will be described of comparative trajectories based on forecast and actual meteorological charts over distances of the order of 1000 km (roughly the distance from London to southern Norway). It shows that the root-mean-square error at this range is of the order of 250 km which is roughly the width of Norway as viewed from southern England. Consequently fuel changing based on such forecasts could result in many failures, either misses when a hit was forecast, or vice versa. The quality of forecasting several days ahead is nevertheless improving and it may ultimately become more feasible than it is at present.

NATIONAL SOCIETY FOR CLEAN AIR

46th ANNUAL CONFERENCE
15–18 OCTOBER 1979
SCARBOROUGH

A VISUAL PRESENTATION OF THE EFFECTS OF WEATHER ON POLLUTION

by

Professor R.S. Scorer
Imperial College of Science and Technology

National Society for Clean Air
136 North Street
Brighton BN1 1RG
England

1. INTRODUCTORY NOTE

This version of the paper describes verbally the mechanisms and phenomena which are to be illustrated by photographs. One of the fascinating aspects of air pollution is that it has been an important means of making air motion visible without significantly modifying it. There is one very important exception to this general statement which occurs when the pollution is copious and the motion almost non-existent, and that is an effect of the pollution on the weather.

2. MECHANICS OF DISPERSION

Life depends on the circulation and mixing of the air, for otherwise it would be suffocated in its own by-products. The life of cities is no different from the life of farms in this respect, indeed a farm dweller probably produces more pollution than a city dweller and is only saved from a monkey-house atmosphere by the low density of population. The whole atmosphere is the bad breath of life with the exception of small amounts of smoke, dust, and volcanic and other geological emissions and a few very minor industrial products: for all the nitrogen, all the oxygen, all the carbon dioxide and a great deal of the water vapour are of biological origin. The other components are relatively minute in amount - argon, some water vapour, and what we call pollution.

It is pure misguided rhetoric to speak of "belching chimneys" and "using the atmosphere as a sewer" in a derogatory way: belching and using the sewers are among the most natural of activities.

The by-products of life, and of its secondary activities mainly connected with combustion, are diluted into the main mass of the atmosphere by vertical mixing upwards and horizontal transport by the wind.

3. DILUTION BY THE WIND

The fresh breath of wind which clears air is well known, and its freshness in a city is due almost entirely to the fact that the volume polluted in a given time is proportional to the wind speed. The pollution concentration, in all pollution formulas without exception, therefore contains the factor U^{-1}, U being the wind speed. The quantity U may appear elsewhere in pollution formulas in other guises, for example in the thermal rise of a hot plume, but by far the most important effect is direct dilution.

4. MECHANICAL STIRRING

The wind contains eddies which may be thought of as the wakes of roughnesses on the ground. The eddies are larger and more powerful in a built-up area or over one with trees, cliffs and other obstacles than over an open plain. Our experience may seem to be otherwise, because the drag force caused by these obstacles to the flow slows down the wind and so it seems to a person standing on the ground that the wind is more powerful in "exposed places" i.e. away from the wakes of obstacles. But the ratio of eddy speed to wind speed is much greater when there are obstacles and so pollution is stirred up as a result and carried upwards from the surface.

When the ground is cold or when for some reason the air above is warmer the stirring is inhibited because any parcel of air displaced upwards tends to fall back to its original level of equilibrium. This is noticeable in the evening when the wind appears to weaken because momentum is not as effectively carried down from above as before the ground began to cool, and at the same time smoke from tall chimneys ceases to be carried down to the ground nearby while, at the same time, that from low chimneys is carried upwards less than in the afternoon.

5. THERMAL CONVECTION

In the atmosphere mechanical stirring is usually present together with thermal convection. Ground warmed in the sunshine causes convection currents which carry pollution upwards, and this motion is encouraged by the fact that much pollution is produced by combustion and is therefore associated with a heat source. Thus pollution is usually seen to be rising away from the ground more than the gaseous components rise.

A plume from a chimney which is rising on account of its own buoyancy and making its own thermal convection is visibly bifurcated. One in which the ascent is caused mainly by thermal convection or mechanical stirring of natural origin is much more sinuous and fragmented.

When the wind is light on a sunny day thermal convection may dominate other dilution mechanisms. When the sky is cloudy and the wind strong mechanical mixing is dominant.

Thermal convection is made visible in nature by cumulus clouds which show clearly the turbulent nature of rising air currents which are intermittant and grow larger as they ascend. A good

thermal source such as a power station undoubtedly initiates thermal convection and causes more thermals to ascend from its neighbourhood than from elsewhere. Its thermal output is of the order of a square mile of sunshine.

6. STRATIFICATION

When the ground cools at night the air close to it is cooled and becomes stably stratified, and this in turn inhibits mixing.

During the night the layer of air cooled grows thicker so that pollution from higher and higher sources are prevented from rising under their own buoyancy. Often by sunrise the plume of an industrial chimneys has levelled out into a thin layer, whereas early in the evening it rises up to cloud base under its own buoyancy. When there are cumulus clouds there is no stable stratification below them unless they are small and high and turret-like and clearly do not originate at the warm ground.

All stable layers are not caused by ground cooling. If an anti-cyclone persists for several days the slow sinking motion which accompanies the high pressure causes a warming of the upper air which does not effect the layers beneath them because they cannot sink. These anticyclonic stable layers are most oppressive in mountainous regions when they sink down to the mountain tops and trap air in the valleys where it may become stagnant. The same trapping in valleys does occur on a smaller scale due to ground cooling, and in that case the valley is filled with cool air that has flowed down the hillsides at night while the air away from the hillsides by more than a few metres is not directly cooled.

7. POLLUTION NEAR TO AND FAR FROM THE SOURCE

There is nothing mysterious about pollution near to a known obvious source although people often attribute ground level pollution to tall chimneys because they can be seen and the real source is invisible.

But pollution far from the source is not always well diluted. It may be carried long distances along the surface in an evening but it may travel much further at higher levels without dilution at a stable layer to which it has risen by its own buoyancy.

When the regime changes in the morning and the stable layer is destroyed by thermal convection in sunshine, the polluted air sinks to make way for the warmer air rising from the ground and

arrives there in due course causing a sudden rise in pollution concentration. This mechanism is called fumigation and can cause great nuisance tens of miles away from the source.

8. STAGNATION OF AIR AT LOW LEVELS

The most serious pollution problems undoubtedly occur when air stagnates at the ground. The pollution from vehicles and domestic sources is trapped, and they are the most difficult to abate.

When a haze becomes dense enough the radiation of heat from it into space becomes significant and the air is thereby cooled. At the same time, when the particles are very small, a great deal of the sunshine is scattered back into space. Natural clouds have the same effect but more so. A cloud top is radiating into space like the ground does when there is no cloud: thus the heat "sink" is displaced to the cloud top. Also clouds are very good reflectors and scatterers of sunshine and so they reduce its effect.

The worst situation, and one which deservedly enjoys the worst name - smog - is produced when the cooling, to which pollution may have contributed, causes the condensation of wet fog. Even during the daytime the average temperature of the smog layer may be progressively lowered by the radiation from the top and the scattering of winter sunshine.

All that can be said in favour of smog is that usually the layer is deeper than when there is no natural cloud so that the pollution is actually diluted more in the absence of wind. The layer is stirred from the top downwards where the heat loss is occurring, and smogs often develop a cellular structure like sea fogs do because of the convection. On the other hand a haze does not have this advantage but often remains stably stratified throughout its depth, and seems more concentrated at ground level.

9. STRATOSPHERIC POLLUTION

Although haze has often been seen in the stratosphere and various pollutants have been measured, there is at present no evidence that the photochemical balance has actually been significantly altered by pollution. The suggestions that the ozone content of the stratosphere might be significantly altered by aircraft exhaust is naive because the dispersion throughout the whole volume is such a slow process. Furthermore the models are purely photochemical and have taken no account of the effects the air motion has on the pollution or that changes of chemical

composition might have on the motion. The former of these effects has been included in a very few calculations which turn out to have very different characteristics from the simpler models - which are so seriously at variance with reality as to be nonsense.

The chief feature of the stratosphere is the slow mixing rate and the very great effect of ozone on the motion. There is very little prospect of coming to a reliable solution of this problem in this century, but we can be sure that any redistribution of ozone will cause compensatory motions and chemical reactions which restore the climatological distribution. Evidence is, on the whole, to the effect that the amount of ozone is stable.

The global circulation has only begun to be mapped in the stratosphere in a very crude way, and to establish a representation of the mechanics comparable with what we do have for the troposphere is likely to be for ever too costly to justify routine work similar to weather forecasting.

10. TRANSCONTINENTAL POLLUTION

Since 1965 there have been two well documented cases of red rain caused by Sahara dust in Britain. On the second occasion the dust cloud was seen by satellite. Unfortunately industrial pollution is usually too dilute to be visible that way, and so we are still very much groping with the problem of industrial pollution carried long distances, because it ceases to be a simple air pollution problem and becomes a rain pollution problem. But rain has such a lot of natural pollution, mainly from the sea and natural oxides of carbon, nitrogen and sulphur, that I suspect that the fuel shortage will provide the best solution to problems of pollution across frontiers and across the sea except over short distances.

Bibliography (pictures)

Book "Air Pollution" by R.S. Scorer, Pergamon Press.

Filmstrips: Environment - Air Pollution, Parts I & II by R.S. Scorer Diana Wyllie Ltd.

NATIONAL SOCIETY FOR CLEAN AIR

46th ANNUAL CONFERENCE
15-18 OCTOBER 1979
SCARBOROUGH

METEOROLOGY AND AIR POLLUTION

by

Dr. D.J. Moore,
Central Electricity Research Laboratories,
Leatherhead

National Society for Clean Air
136 North Street
Brighton BN1 1RG
England

1. INTRODUCTION

The natural defence of living organisms against toxic effluents is the great capacity of the atmosphere to dilute and in many cases subsequently to rid itself of these materials. The mechanism which ensures the dilution of effluent gases necessary to enable life to exist is atmospheric turbulence. This turbulence is produced in two ways. Firstly, by the stirring of the wind caused by the drag of the surface and objects projecting from it and secondly by convection currents rising from the surface when the surface is warmer than the air.

At a particular location for a given wind direction, the depth of the turbulent layer (the mixing layer) is determined by the strength of the wind and the degree of surface heating. It follows that, for low-level sources near a surface receptor, dilution is at a minimum when the surface is colder than the air (i.e. there is no convection) and there is little or no wind.

This is not true for emission from tall chimneys or from sources which have a large initial buoyancy. In conditions of reduced turbulence near the ground, the mixing layer is very shallow and plumes from these sources will rise above it into the 'free atmosphere' where turbulence is almost always very low. Effluent from such sources will not be detected at the ground until conditions change and the turbulence originating at the surface reaches the height at which their plumes finally level out. The greatest ground level concentrations for high sources will, therefore, occur in conditions of either strong winds or strong convective activity. Even in these conditions, proper stack design csn ensure dilution of the stack gases by factors of the order of 10^4 at ground level providing the gases are buoyant. This may be compared with reductions in source strength by factors of 2 to 200 achieved by most control processes.

A full discussion of atmospheric transport and diffusion processes would, of course, take a whole book. The purppse of this paper is therefore to bring the more important features of these processes to the attention of the reader and to direct him towards more detailed descriptions.

2. THE MIXING LAYER

If we consider a type of surface to begin at some well-defined topographic or topological discontinuity, e.g. the coast, the boundary between hills and plains, the edge of an extensive urban area, then an approach to an equilibrium boundary layer

will be reached only after a time of travel greater than the ratio of the momentum of the air stream to the body forces acting on it. As these forces include the effect of the rotation of the earth, this ratio will be of the order of the inverse of the Coriolis parameter, which in middle latitudes is 10^4 s. Thus, for fetches less than 10^4 times the wind speed (in ms^{-1}), the boundary layer should be considered as a growing or an 'internal' boundary layer. A discussion of the growth of internal boundary layers is given, for example in Pasquill, 1972. (1)

In addition to the fetch, the properties of the mixing layer over a given type of surface will depend upon the following external factors:

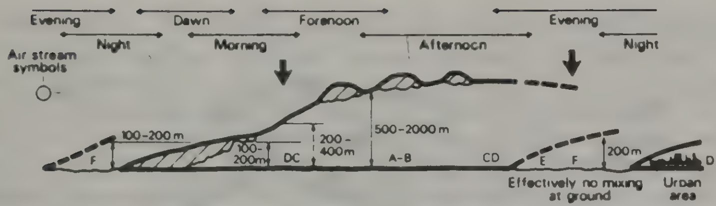
(a) The properties of the incident air stream (i.e. its condition as it arrives over the windward edge of the type of surface being considered).
(b) The roughness characteristics of the surface considered.
(c) The free stream or surface geostrophic wind speed (U_G).
(d) Some property determining the magnitude and direction of the heat flux between the air stream and the surface considered.

It is difficult to express (d) as an external parameter as all the relevant properties (e.g. potential temperature difference between the air at some level and the surface, surface heat flux, Richardson number at some level, Monin-Obukhov length at some level) will all, to some extent, be determined by factors (a)-(c). It is customary to estimate one of the above and use this as the independent variable. Definitions of Richardson number and Monin-Obukhov length are given, for example in Pasquill, 1974. (2)

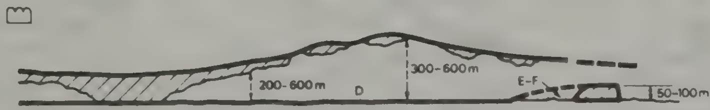
Where horizontal temperature (i.e. density) gradients exist, there is a variation in the pressure gradient and hence in the geostrophic or free stream wind velocity with height, in addition to the shear due to surface friction. In this case there may be appreciable turbulence exchange at heights well above the top of the 'barotropic' mixing layer, Wippermann, 1973. (3).

3. METEOROLOGICAL FACTORS DETERMINING AIR STREAM CHARACTERISTICS

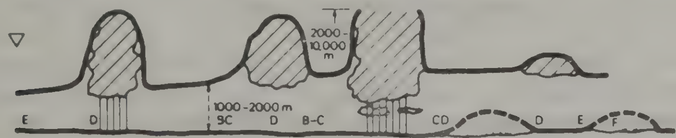
Features (a), (c) and (d) of Section 2 will, to a large extent, be determined by a combination of factors depending on the large-scale features of the pressure system affecting the site at the time and on diurnal heating or cooling of the surface. Fig. 1 gives vertical time sections over land showing the properties of the mixing layers generated by each of the principal air stream types. Fig. 2 shows the locations of the air streams in relation



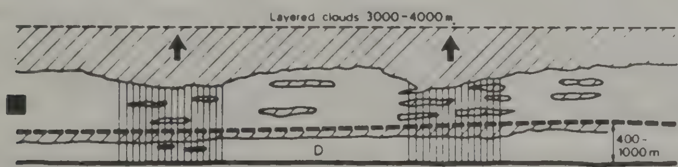
a. Settled, anticyclonic - Turbulence mainly convective in origin.



b. Warm advection - Turbulence mainly mechanical in origin.
On-shore wind at night, off-shore wind in day.



c. Cold advection - Turbulence convective mechanical.
Land breeze, sea breeze.



d. Unsettled cyclonic - Turbulence mechanical.
Thick layered cloud inhibits diurnal variation.

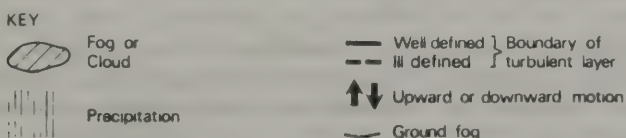


Fig. 1. Time sections of the lower atmosphere in each of the four principal air stream types of middle latitudes. The time axis is calibrated in general terms (morning, afternoon etc.) as the actual times will vary with location and time of year. The heights are indicated at various points along the time scale as these again will be functions of location, time of year etc. The corresponding 'Pasquill' categories are indicated by capital letters just above the surface.

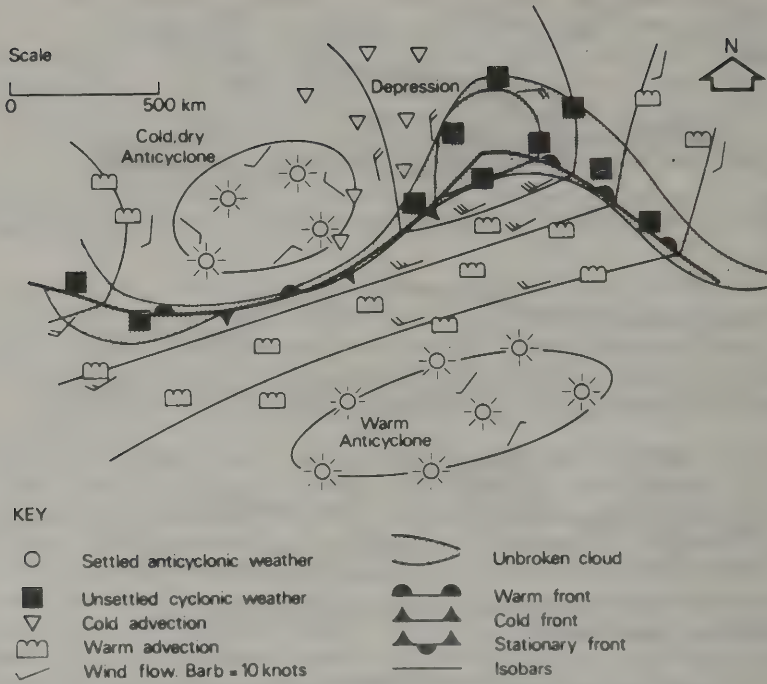


Fig. 2. Locations of principal air stream types in relation to typical features of a middle latitude (Northern Hemisphere) surface, synoptic weather map.

to typical features of a middle latitude synoptic weather map. Each of these air stream types will now be discussed briefly.

4. SETTLED ANTICYCLONIC (FIG. 1a)

The principal dynamic features of these air streams are:

(i) Large-scale divergence (i.e. flow outwards from the high-pressure centres) across the isobars and corresponding subsidence (descending motion) in the lower half of the troposhere.

(ii) The descending air above the mixing layer has a stable vertical temperature gradient and low humidity.

(iii) The wind speeds are light or moderate.

(iv) Turbulence in the mixing layer is typically convective in origin.

The typical diurnal history of the mixing layer is shown in Fig. 1a.

Under clear skies at night a surface radiation inversion develops (over rural areas) leading to very low levels of turbulence (2)

and consequently extremely restricted turbulent diffusion, so there is no effective mixing layer. Later in the night, if the air near the surface is sufficiently moist, fog will form. If the fog is deep enough, the maximum radiation cooling will be transferred from the surface to the top of the fog layer. Convective turbulence will then develop in the fog layer and any low level emissions of pollutants will become well mixed through the fog layer. The top of the mixing layer is now the top of the fog.

As the sun rises, the surface will be warmed sufficiently for the fog to evaporate near the ground, low stratus cloud will develop and may eventually disperse. Further surface heating then results in the depth of the boundary layer continuing to increase and again, if there is sufficient moisture present, fair weather cumulus cloud will form later in the forenoon.

The convective thermals will penetrate some distance into the stable capping layer of dry subsiding air and some of this air will be fed into the top of the mixing layer, helping the warming process, Carson, 1973 (4). As the intensity of solar radiation begins to decline after noon, the supply of heat will eventually be insufficient to maintain the warming process and shortly after the maximum temperature is reached the air near the surface will begin to stabilize. The large scale turbulence at higher levels will then dissipate, as the supply of further energy from the surface is cut off, and the diurnal cycle is then complete. This is the classic air pollution situation for low level emissions. Modifications due to the presence of surface features and the importance of effective emission height on pollutant behaviour in these conditions will be discussed in Sections 9 to 11 below.

Over the sea, the airstream may become moist and unstable through a shallow layer near the surface. Cloud which forms at the top of this layer may be slow to clear as it drifts inland in winter, giving anticyclonic gloom with little diurnal variation in mixing properties.

5. WARM ADVECTION (FIG. 1b)

Warm advection occurs when the underlying surface is cooler than the surface upwind. Typical examples over north-west Europe are the south-westerly wind in the warm sector of a depression or the southerly flow ahead of warm fronts (Fig. 2).

The principal features of this type of air stream are:

(i) A deep, stably stratified flow with high humidity.

(ii) Moderate or strong winds.
(iii) Little organized vertical motion, mainly weak subsidence.
(iv) Turbulence in the mixing layer, mainly mechanical; some weak convection over land during the day.

The diurnal history is illustrated in Fig. 1b.

Overnight there will be extensive low cloud; this may well reach the surface as sea or hill fog. Diurnal heating may burn off the cloud, or at least cause it to break, but the diurnal range in mixing layer height will be much smaller than in an anticyclonic situation. At a sufficient distance from the coast, if the cloud has been dissipated by surface heating and the wind speed is light enough, a surface radiation inversion and fog patches may develop in the evening. However, in maritime locations low stratus cloud will usually spread over the area from the direction of the coast later in the evening, causing the surface air to warm again and a mechanically stirred mixing layer to re-form.

6. COLD ADVECTION (FIG 1c)

These streams occur typically on the western sides of low pressure areas (Fig. 2) and also locally as a result of sea breezes and shallow katabatic winds (see Sections 9 and 10). The potential temperatures at heights up to several thousand metres are lower than those at the surface, except intermittently during the night and in subsiding air between clouds.

Other features of these streams are:

(a) Winds moderate or occasionally strong.
(b) Convective cloud often giving showers.
(c) Clear subsiding air between the clouds may give locally limited mixing depths corresponding roughly to the cloud base.
(d) Turbulence - partly mechanical, but the mixing depth is controlled largely by the convective instability.
(e) Little net vertical motion.

The diurnal history is shown in Fig. 1c. Winds and shower activity may be insufficient to prevent some stabilization of the surface air after sunset, but any fog patches will be shallow and clear if convective clouds move overhead at times during the night, but in any case soon after sunrise. The radiational cooling under clear skies may be very rapid because of the low humidity.

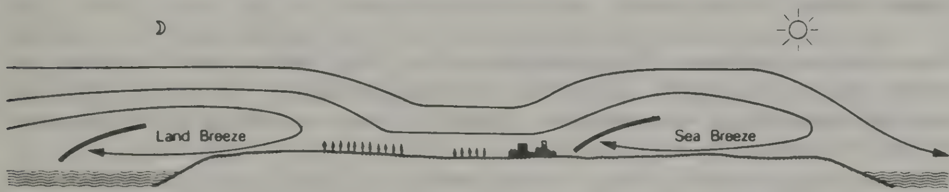
7. UNSETTLED CYCLONIC (FIG. 1d)

These streams show fairly rapid changes in wind direction and

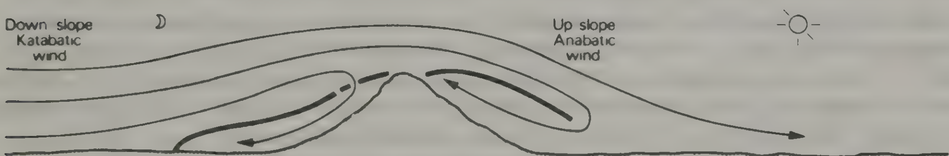
generally overcast skies, often with rain. A general upward vertical motion and the baroclinic nature of the flow often result in an ill-defined top to the mixing layer. However, in some situations the presence of a warm moist air mass above may lead to a sharp temperature inversion restricting vertical mixing. There will be a component of flow across the isobars towards the low pressure. Turbulence near the surface is mainly mechanical in origin and there is little diurnal variation.

8. FREQUENCY OF OCCURRENCE OF DIFFERENT SITUATIONS

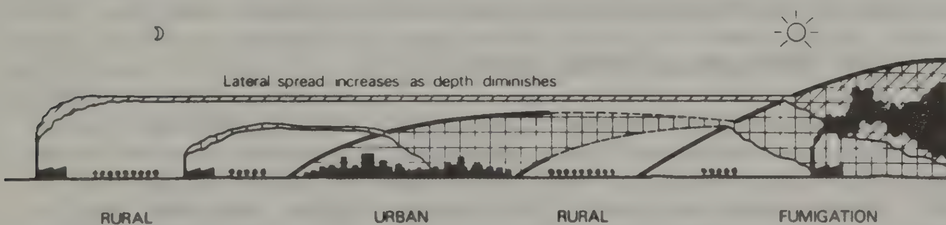
The frequency with which the different types of air streams will occur at a given site will depend upon its geographical location. They will often be associated with a particular wind direction.



a. Land and sea breezes.



b. Up slope and down slope winds.



c. Urban areas and elevated sources.

Fig. 3. Effect of surface features; (a) coasts; (b) high ground; and (c) urban areas and source height on pollutant dispersion.

For the UK, a rough breakdown would be:

- Settled anticyclonic, 30% (variable, often NE to E wind);
- Warm advection, 50% (SE to W wind in Summer, W and SW in Winter;)
- Cold advection, 10% (NW to N wind in Summer, NW to S through E in Winter;)
- Cyclonic, 10% (variable).

9. LAND AND SEA BREEZES

When the pressure gradient is slack, i.e. mainly in settled, anticyclonic conditions, the temperature difference between land and water leads to flow from the cooler towards the warm surface. At some height (usually 1000m) and at some distance (up to 80km) from the shore, the normal flow will be maintained, Slade, 1968. (5)

Thus this situation, illustrated in Fig. 3a, leads to a limited mixing depth situation and also, in circumstances in which the land or sea breeze opposes the general flow, to the possibility of recirculation of pollution.

10. UPSLOPE AND DOWNSLOPE WINDS

Local winds also develop when air cooled by radiation at night over upland regions runs downhill to displace warmer air at lower levels (Fig. 3b). These katabatic winds are usually turbulent and in narrow valleys or fjords can be quite strong. Mixing within the stream will be quite efficient but there will be little exchange between the cold air stream and the warmer air above it. On the other hand, when low ground is covered with fog in the early morning, and the upper slopes clear, the differential heating may cause upslope (anabatic) winds to develop (Fig. 3b). The top of such circulations is generally limited by the snow line.

11. URBAN AREAS AND ELEVATED SOURCES

An urban area enjoys its own microclimate and the reduced levels of turbulence associated with radiation inversions in rural areas are seldom encountered in built-up areas, Bringfelt et al, 1974. (6). Temperatures are also a few degrees higher than they are in rural areas in light winds, W.M.O., 1970. (7). The consequence of these effects is that the urban area develops its own internal boundary layer and that low-level emissions which are trapped within this layer become well mixed within it (Fig. 3c).

In settled anticyclonic conditions at night the warmer urban air rises above the cooler rural air on the lee side of the city,

and an 'urban plume' drifts down-wind. As the convective boundary layer develops over the rural area during the morning, the urban plume will eventually be brought down to the ground (right-hand side of Fig. 3c), leading to a rapid increase in ground level pollution. As the mixing depth increases, the concentration will fall from this peak fumigation value, Martin and Baker, 1973. (8).

Fig. 3c also illustrates some features of the behaviour of plumes from elevated sources. These will generally level out at some height depending on atmospheric conditions, stack height and heat emission rate. The initial dilution caused by turbulence due to relative motion will be much greater than that experienced by inert tracers and will generally be comparable to that from a point source at 10 to 20 km upwind in 'Pasquill F', Moore, 1973, (9), conditions by the time the plume has travelled a few hundred metres. If the air stream at plume level is stably stratified, the depth of the plume will diminish (Fig. 3c) under the action of gravity forces as it drifts further downwind, resulting in additional lateral spread, with the result that the plume width is often greater than in a neutral boundary layer, Moore, 1973. This again differs from the behaviour of inert plumes, which usually show a much reduced lateral spread, Singer et al, 1966. (10)

As the plumes from elevated sources drift over urban areas at night, they may be fed into the urban boundary layer, or they may pass over it (middle of Fig. 3c) depending on the amount of plume rise, the chimney height and the depth of the mixed layer. Pollution from low level sources in the urban area will be at its worst when the mixing depth is shallowest and the winds within it at their lightest. In these conditions, the tall chimney plumes will have a high plume rise and so make no contribution to the ground level pollution. On the other hand, the tall chimney plumes will give their highest ground level concentrations when there is strong convective turbulence up to the plume centre line, conditions in which the pollution from level sources will be relatively well dispersed.

ACKNOWLEDGEMENTS

The paper is based on Chapter 10 of the book 'Air Pollution Analysis' edited by R. Perry and R. Young with the permission of the publishers, Chapman and Hall. It is published by permission of the C.E.G.B.

REFERENCES

(1) Pasquill, F., 1972, Some aspects of boundary layer description, Q.J. Roy. Meteor. Soc. 98, 469-494.

(2) Pasquill, F., 1974, 'Atmospheric Diffusion' (2nd edition), Ellis Horwood, Chichester.

(3) Wipperman, F., 1973,The planetary boundary layer of the atmosphere Deutscher Wetterdienist, Offenbach.

(4) Carson, D.J., 1973, The development of a dry inversion - capped convectively unstable boundary layer, Q.J.R. Meteor. Soc. 99, 450-467.

(5) Slade, D.H., (ed.), 1968, Meteorology and atomic energy, U.S.A.E.C.

(6) Bringfelt, B., Hjorth, T, and Ring, S., 1974, A numerical air pollution dispersion model for central Stockholm, Atmos. Environ. 8, 131-148.

(7) W.M.O., 1970, Urban climates, Technical Note No. 108.

(8) Martin, A. and Barber, F.R., 1973, Further measurements around modern power stations, Atmos. Environ. 7, 17-38.

(9) Moore, D.J., 1973, Predicting the concentrations of effluent material within a plume emitted from a tall chimney, Faraday Symposium of the Chemical Society, No. 7, 222-228.

(10) Singer, I.A. and Smith, M.E., 1966, Atmospheric dispersion at Brookhaven National Laboratory, Air and Wat. Poll. Int. J. 10, 125-136.

NATIONAL SOCIETY FOR CLEAN AIR

46th ANNUAL CONFERENCE
15-18 OCTOBER 1979
SCARBOROUGH

GENERAL METHODS OF MEASUREMENT AND MONITORING

by

Dr. A.W.C. Keddie
Warren Spring Laboratory

National Society for Clean Air
136 North Street
Brighton BN1 1RG
England

1. INTRODUCTION

The term "monitoring" is the one most commonly applied to the measurement of air pollution but the usage tends to be rather loose, the precise meaning depending on the predilections of individual users. In this paper the term is applied to the systematic measurement of pollution in time and/or space: a briefer but essentially identical definition to that recently given by Reay in his paper on "Philosophy of Monitoring" (1). I do not intend to discuss the philosophy of monitoring or the details of the design of monitoring networks in this paper. Nevertheless, it is important to stress that effective monitoring requires of its practitioners not only a sound knowledge of the instrumental and analytical methods being employed but also a full appreciation of the relevant space and time scales in the ambient atmosphere of the pollutant(s) in question, which in turn means a good understanding of the physical and chemical processes governing ambient air quality. Even with the best of intentions, the thoughtless deployment of instruments, the continuing development of methods without due recognition of practical requirements and constraints or the routine collection of data without any clear objectives as regards presentation, interpretation and ultimate use invariably lead to disenchantment and criticism; such activities should be strongly discouraged.

The scope of this paper is confined to the more traditional monitoring systems where continuous or discrete samples are extracted from the atmosphere and the samples analysed automatically in-situ or returned to a laboratory for analysis. Of course, in recent years non-extractive systems, such as remote sensing techniques, have been improving and their application to air pollution monitoring is growing but Dr. Varey and Mr. Green discuss these systems in the following paper. What I want to do is to outline the more important national monitoring activities which have been carried out in the U.K. during the past 20 years or so while at the same time draw attention to the influence of changing requirements and of improved technology. Existing monitoring networks or methods are subject to change because of many influences among the more important of which are:

(i) Data on the concentrations of a particular pollutant obtained from relatively sparse monitoring locations and using relatively crude methods raised further questions on the temporal or spatial variability of the pollutant and may also, for example, point to the need for greater accuracy. This can lead to the deployment of more sophisticated instruments or even to the development of the necessary instrumentation.

(ii) Monitoring of air quality in an area can begin with a pollutant which is relatively easy and cheap to measure but then leads to the desire to include other less easily measured species in order to complete the "picture".

(iii) Experience of occupational exposure or increased emissions or some "incident" or new effects evidence may create sufficient concern about the possible exposure of the general population to a pollutant to warrant monitoring, at least on a limited scale.

(iv) The introduction of air quality objectives or standards can, for example, lead to the redesign of an existing monitoring network, to the need for greater accuracy or to the need for better temporal resolution.

(v) Advances in technology can make certain types of measurement possible or economical where previously they were not.

(vi) Particular data on ambient air quality may be required for effects studies or for the validation of dispersion models.

2. NATIONAL SURVEY OF SMOKE AND SULPHUR DIOXIDE

The National Survey of Smoke and Sulphur Dioxide is the longest established and by far the most comprehensive spatially of the U.K. monitoring activities. Furthermore, the methods employed are relatively simple and the Survey therefore makes an excellent starting point and base-line example.

For fuller details of the National Survey, its history and the methods of sampling and analysis used, the reader is referred to "National Survey of Air Pollution 1961-71", Volume 1 (2). Summarizing, the Survey was established in its present form in 1960 and at that time there were some 475 monitoring sites in operation. The size of the Survey grew steadily to a figure of about 1200 sites in 1966 and has remained at approximately that size since then, although there is an average annual turnover in sites of about 8%. Most of the sites are in urban areas, only about 140 being located in rural communities and in open country. Whilst Warren Spring Laboratory acts as the co-ordinating and data/publishing organisation on behalf of the Department of the Environment, the sites are operated primarily by local authorities and also by other organisations such as the Central Electricity Generating Board. Concentrations of smoke and sulphur dioxide are obtained by continuous sampling of the atmosphere for a 24h period, the sampled air passing through a filter paper to remove the particulates, then

through a drechsel bottle containing hydrogen peroxide to remove the sulphur dioxide and then through a gas meter to measure the volume of air. The darkness of the stain on the filter is measured using a simple reflectometer and converted to an equivalent weight of standard urban smoke. The acidity of the exposed hydrogen peroxide is determined by simple titration and is assumed to be due entirely to sulphur dioxide in the atmosphere. The values so obtained are 24h average concentrations of smoke and sulphur dioxide expressed in units of $\mu g/m^3$. It must be stressed, however, that the smoke figure is not an accurate measure of the concentration of suspended particulates in the atmosphere, it is a measure of the blackness of the particulates, and the sulphur dioxide figure obtained in subject to interference from alkaline or other acidic gaseous compounds in the atmosphere. The accuracy of the methods also deteriorate rapidly at low concentrations (say, below 10 $\mu g/m^3$ for smoke and 25 $\mu g/m^3$ for SO_2). Despite these limitations the methods do give reliable data on smoke and sulphur dioxide concentrations, provided adequate attention is paid to quality control and the recommended procedures are adhered to. Major advantages include the relatively low capital costs and the simplicity of the sampling instrument and analytical methods which in turn mean that the measurement part of the Survey can be carried out by relatively unskilled staff. Some typical current cost figures are given in Table 1.

Table 1 National Survey Instrument Costs and Effort *

Cost of single - port daily instrument (one visit per day)	:	£275
Cost of semi-automatic 8 - port instrument (one visit per week)	:	£500
Cost of reflectometer	:	£300
Annual costs of reagents, pump repairs, etc for 10 sites	:	£250
Annual effort required to operate 10 sites (semi-automatic type)	:	0.5 man

* The effort given in this and subsequent tables does not include reporting and interpretation of the results.

The National Survey is, in practice, essentially representative of the urban areas in the U.K. and is capable of providing trends and of delineating the broad spatial distribution of the two pollutants. However, considerable care must be exercised on the more local

scale when interpreting the observations for individual towns which, in many instances, may be available for only one or two monitoring sites, not always ideally suited for the purpose. In such cases considerable reliance must be placed on experience and on knowledge of site surroundings when assessing the significance of the observations. Great care must also be taken when interpreting the results obtained from sites in rural areas because in these areas concentrations are low and accuracy is generally poor, especially for sulphur dioxide. Nevertheless, the methods are adequate to demonstrate reliably the broad differences between urban and rural concentrations even if the small differences in concentrations observed at the rural sites cannot be accurately determined; measurement of sulphur dioxide carried out by Warren Spring Laboratory at a few country sites using the more accurate Thorin method (3) have confirmed the broad conclusions drawn from the National Survey data.

National Survey observations are published annually (4) and have been analysed and presented in several different ways during the past 18 years or so. Initially the analysis of the data was relatively simple being confined to the provision of U.K. and Regional trends, comparisons with trends in U.K. emissions of smoke and sulphur dioxide and discussions of observations made in individual towns and at individual sites (see, for example, reference 2 and the other 4 volumes in the series and reference 5). Trend data are now published regularly in the "Digest of Environmental Pollution Statistics". (6) More recently, the analysis of the data has been considerably extended in scope and sophistication and now includes comprehensive statistical treatment, maps of the distribution of smoke and sulphur dioxide throughout the U.K. and the use of the data for dispersion model validation.

Average annual smoke concentration in urban areas have decreased by some 80% between 1960 and 1977 dramatically demonstrating the success of the 1956 Clean Air Act and in particular the replacement of coal by solid smokeless fuel, gas and electricity in residential properties. Rural data are not available for such a long period of time but the more recent data suggest that significant percentage reductions have also taken place in rural areas. Urban average sulphur dioxide concentrations also decreased (by about 55%) during the same period despite the fact that total emissions changed little. The main reason for this has been the growing proportion of emissions of sulphur dioxide from power stations, with their high chimneys, and a commensurate reduction in emissions from industrial, commercial and residential premises, the last category being especially important. The observations for

rural areas, covering a shorter and more recent period, show no clear trend, which is consistent with the small changes in <u>total</u> emissions.

Concentrations of both pollutants exhibit considerable spatial and temporal variability. The spatial distributions of winter and annual concentrations closely follow the spatial distributions of emissions from chimneys of low and medium height (7); local meteorological and topographical factors are of much less importance in this respect. Consequently the highest concentrations are, in general, to be found in the conurbations and in the larger towns and give way rapidly to much lower concentrations (5-20% of the central urban values) in rural areas, (8) although relatively high smoke concentrations are observed in the smaller towns where domestic coal consumption is still high. Daily concentrations of smoke and sulphur dioxide at any given location approximate to log-normality and the range observed during any one year is typically 50-100:1.

During the last 3 years the National Survey data have been invaluable when examining, for example, the implications of the proposed EEC Directive on Health Protection Standards for Suspended Particulates (Smoke) and Sulphur Dioxide. It has been possible to delineate the areas exceeding the proposed standards and to rapidly assess the implications of suggested changes. Moreover, despite the simplicity of the Survey it should be entirely adequate to fulfil the U.K's monitoring obligations under the Directive, albeit perhaps after some rationalisation in co-operation with the Local Authorities and other organisations operating the sites.

3. OTHER MONITORING ACTIVITIES

This part of the paper is devoted to an outline of some of the studies carried out by Warren Spring Laboratory since 1970 to determine the concentrations of a variety of pollutants other than smoke and sulphur dioxide. Although the instrumentation for these studies have been purchased by Central Government and the studies have been conducted by Warren Spring Laboratory staff, in all cases the staff of Local Authorities and other organisations have provided considerable assistance in the selection of appropriate monitoring locations and in the operation of the monitors.

<u>Studies Involving Chemical Analysis at a Central Laboratory</u>

Several of the studies have involved the collection of samples (e.g. on filters) at the monitoring locations followed by the

chemical analysis of the samples at Warren Spring Laboratory. Within this category come the Multi-element and Sulphate Surveys (9) each of which consisted of 20 urban sites respectively set up to monitor 16 elements (e.g. Pb, Cd, Mn and V) in suspended particulates and sulphate in suspended particulates. These were pilot surveys to determine whether or not any potential "problems" existed and to determine the typical temporal and spatial variations of the various species. There are considerable difficulties in obtaining samples of particulates which are representative of what is in the ambient atmosphere. For example, the National Survey instrument is not entirely adequate for this purpose and therefore samplers were designed and constructed at WSL for the two surveys (9). These two types of sampler are relatively cheap by present day standards (see Table 2) but access to relatively sophisticated and expensive analytical equipment is essential and the effort devoted to the operation of the sites and to the chemical analysis is substantial (Table 2). The analytical methods used were Atomic Absorption and Emission Spectrography for multi-elements and X-Ray Fluoresence for sulphates. The sampling rates and periods were matched to the aerodynamic characteristics of the sampling head/filter assemblies of the instruments, to the filtration efficiences of the filters used and to the sensitivity of the analytical methods. A 24h sampling period was selected for sulphates (i.e. the same as for the National Survey) and each sulphate instrument was equipped with an 8-port changeover valve to limit site visits to one per week. For multi-elements the basic sampling period chosen was one week and the exposed filters for 4 or 5 week periods were batched together before analysis, effectively giving monthly samples. The minimum detectable concentration for sulphates was 0.3 ug/m^3 and for the multi-elements the minimum lay in the range of 0.05 - 5 ng/m^3 (nanograms per cubic metre).

The two networks were in continuous operation during the period April 1976 to March 1978. The mean concentration of sulphates, averaged over the 20 sites, was about 10 $\mu g/m^3$ compared with the corresponding sulphur dioxide concentration of about 70 $\mu g/m^3$. The spatial distribution of sulphates was found to be much more uniform than is the case for sulphur dioxide substantiating the view that sulphates are, to a large extent, a secondary pollutant produced by the oxidation of sulphur dioxide (10). On the other hand sulphates do show a similar degree of temporal variability to that of sulphur dioxide and also approximate to log-normality. The multi-element results are too numerous to cover individually here but a full analysis has been published (11). Iron, lead and zinc tended to be found in the most abundance with respective maximum monthly concentrations of 6.3, 1.8 and 7.0 $\mu g/m^3$. Other elements - arsenic,

Table 2 Multi-element and Sulphate Surveys: Instrumental and Analytical Costs and Effort

Cost of multi-element sampler :	£375
Cost of sulphate sampler :	£425
Annual cost of durables, repairs, etc for 20 sites :	£2,000
Annual operational and analytical effort required for 10 multi-element sites :	1.0 man
Annual operational and analytical effort required for 10 sulphate sites :	0.8 man
Cost of atomic absorption instrument :	£ 4,000-£12,000
Cost of emission spectrograph :	£30,000-£50,000
Cost of X-Ray fluoresence instrument :	£60,000-£100,000

beryllium, cadmium, cobalt, germanium, molybdenum and antimony - tended to be found at concentrations below 0.01 $\mu g/m^3$. Some association between local potential sources of specific pollutants and above average concentrations of these pollutants were found, perhaps the most marked being the dependence of lead concentrations on road traffic.

Some shorter term studies involving relatively simple monitoring instrumentation and sophisticated analytical equipment include:

i) The measurement of multi-elements in the vicinity of potential local sources in the West Midlands (12). The sampling instrument used was an earlier version of the multi-element sampler referred to above but the analytical methods were similar.

ii) The measurement of airborne mercury concentrations around selected probable sources in the U.K. Mercury is found in the vapour phase and in particulate form so that at least two samplers are required at each site. Two sampling methods were in fact used to collect mercury in the vapour phase. The first consisted of acid-permanganate bubblers connected to standard sampling inlet, 8-port changeover valve, pump and gas meter trains. The bubblers are arranged such that when sampling commences the potassium permanganate solution in the first bubbler is sucked into the second bubbler containing sulphuric acid, thus effectively pre-

paring a fresh acid - permanganate solution which ensures efficient capture of mercury. The second method used a similar sampling train except that a charcoal packed silica replaced the bubblers. The particulate mercury was trapped on Millipore membrane filters.

Filters were exposed for one week and carbon tubes and bubblers were exposed for 24h. Flameless atomic absorption was used to determine the amount of mercury present after pre-treatment of the samples, appropriate to the method of collection, in the laboratory.

iii) The determination of ambient concentrations of airborne vinyl chloride monomer (VCM) around factories which are major users in the U.K. The method of sampling and analysis used was based largely on work done by ICI Mond and Plastics Division; it was adapted for field use by WSL. Each sample was obtained by drawing air for 24h through activated carbon contained in copper tubes. Two tubes were used in series because of the risk of migration and breakthrough under certain conditions. Again automatic 8-port changeover valves were incorporated into the sampling system to reduce site visit to one per week. On receipt of the samples at WSL the VCM was desorbed into cooled Analar carbon disulphide before being analysed using gas chromatography (see Section 4 on Odours).

Automatic Continuous In-situ Monitoring

Where it is necessary to obtain much better temporal resolution than 24H (say 1h or 5 minutes) continuously over an extended period of time then it is not practicable to collect samples for subsequent analysis in a laboratory. One must resort to instrumental methods capable of providing determinations of the pollutant in question automatically at the prescribed frequency and sampling period. For example, it has been well established that the contributions to ground level concentrations of sulphur dioxide from a modern power station are very difficult to identify over sampling periods of 24h and greater (13). Consequently, in order to monitor effectively the more substantial shorter period contributions instruments with a resolution of 1h or less are required. In a study in the Forth Valley of Scotland WSL used sulphur dioxide instruments, working on the flame photometric detection principle, to obtain concentrations at 5 minute intervals at 6 locations for a period of 1 year. All such automatic instruments (including those for other gaseous pollutants) produce

a d.c. voltage which is proportional to the concentration. The voltage is recorded by a data acquisition system which usually incorporates paper or magnetic tape for subsequent computer processing and analysis. Whilst these types of systems produce vastly more information there are substantial penalties in terms of the cost of the monitoring instruments and data loggers (for sulphur dioxide up to 20 times more costly than a basic National Survey 8-port instrument), a greater degree of unreliability, the need for high quality instrument calibration facilities, the need for much more highly skilled operating and maintenance staff and the need for a central computing facility (see Table 3).

There are also pollutants for which only automatic in-situ instrumental monitoring offers sufficient selectivity (specificity) or sensitivity even although short time scale variations of the pollutant concentrations may not be required. Oxides of nitrogen and ozone are typical examples.

The most comprehensive study carried out by WSL involving a range of automatic instrumentation is the current Hydrocarbons, Oxides of Nitrogen and Ozone Survey which has succeeded the 5 Towns Survey of Kerbside Pollution (14). Carbon monoxide and sulphur dioxide are also monitored at some of the sites. The original project began in 1972 and was primarily aimed at monitoring the impact of motor vehicle pollution on the air quality of busy city streets and the sampling points were located at the kerbsides of major roads carrying between 10,000 and 55,000 vehicles per day. An additional inner-city, off-street site (urban background site) was set up in Central London so that kerbside data could be compared with general urban concentrations of pollutants. Measurements of total hydrocarbons (THC), and carbon monoxide (CO) were made at all locations with the London sites measuring oxides of nitrogen (NO and NO_2) and sulphur dioxide (SO_2). Ozone (O_3) was also measured at the London off-street site. More recently, the kerbside sites have been closed down, with the exception of those in London and in Glasgow, but at the same time NO and NO_2 measurements have been added at the Glasgow site, the London urban background monitoring has been extended and measurements are also being made at Canvey on the Thames Estuary and at a site near to the east coast of Suffolk.

The methods of measurement used in this study, together with the costs of the instruments, are given in Table 3 and Table 4 gives data logger and operating costs (15). A proportion of the effort included in Table 4 is to cover the continuing developments in technology which are an inevitable component of this type of

monitoring.

Lead (Pb) and Smoke concentrations have also been monitored at the kerbside sites using sequential filter tape samplers. The Pb was determined by X-ray fluoresence and the smoke by the standard National Survey reflectometer.

The long term character of this survey means that the results give a good indication of the concentrations of air pollutants experienced in busy streets over a wide range of meteorological conditions. The continuous record of data may be studied for evidence of trends and for variations in the hourly, daily and longer term patterns of individual pollutants as well as for differences between the individual pollutant patterns. These differences, etc give some indication of the relative responsibility of mobile and stationary sources to pollutant concentrations and the following broad conclusions have been drawn (14,16):

Table 3 Instrumental Methods for NO, NO_2, etc. and Their Costs

Pollutant	Instrumental Method	Cocentration Range	Cost
THC	Flame ionisation	0.1 - 50 ppm	£1000-£2500*
CO	1. Non-dispersive infra-red absorption 2. Continuous coulometry	0.1 - 100 ppm	£1000-£5000
NO NO_2	Ozone chemiluminescence (single instrument)	0.01 - 2 ppm	£4500-£9000
O_3	Ethylene chemiluminescence	0.005 - 0.5 ppm	£1500-£3000
SO_2	1. Flame photometry 2. Continuous coulometry	0.005 - 1 ppm	£3500-£7000

*Add a further £1000 - £5500 if non-methane hydrocarbons are included

Table 4 Data Logger and Operating Costs

Cost of a data logger (magnetic or paper tape for subsequent computer reading)	:	£1500–£4000
Annual cost of calibration gases, spares, etc for 10 instruments	:	£3000
Annual effort to operate 2 sites (5 instruments at each)	:	2.1 men

---

i) In general, urban concentrations of CO and Pb arise predominately from motor vehicles.

ii) Motor vehicles make a substantial contribution to kerbside concentrations of NO but there are indications of significant contributions from stationary sources.

iii) Non-vehicle sources contribute significantly to kerbside concentrations of total hydrocarbons but there are wide differences in the strength and pattern of the contribution between different locations.

iv) Motor vehicles make at most a very minor contribution to kerbside SO_2 concentrations but they do make a substantial contribution to smoke concentrations and in many locations they are now the dominant source.

v) Kerbside NO_2 concentrations are generally only slightly influenced by vehicles actually in the street. The relative responsibilities for general urban concentrations of NO_2 and O_3 are not clear. This is primarily because both pollutants are the product of chemical reactions in the atmosphere (typically only 10% or less of the oxides of nitrogen are emitted as NO_2) and the reaction times make it difficult to quantify the contributions from the different sources.

The more reactive hydrocarbons play an important role in the photochemistry of pollutants and in particular the production of NO_2 and O_3 in the ambient atmosphere (17). Although total hydrocarbons can fairly readily be divided into the methane and non-methane fractions in-situ (e.g. by incorporating a catalytic oxidiser), the necessary quantification of the different species requires sophisticated analytical facilities such as gas chromatography, often coupled to mass spectroscopy. For this type of work it has been

necessary to obtain samples using various trapping techniques and then returning the samples to a central laboratory for analysis. WSL has just embarked on a study of this type using the techniques developed for odours (see next section) but it barely falls within the definition of "monitoring" given in the Introduction.

4. THE MEASUREMENT OF ODOURS

There are three main characteristics of odours which make their routine measurement currently impossible:

i) The extremely low concentrations of the compounds concerned at which an odour can be detected by the human nose; in most cases at least one order of magnitude less than the concentrations at which the compounds have toxic effects.

ii) The human nose will detect an odour even if exposed for only a few seconds.

iii) Many odours are caused by emissions containing a large number of components and the intensity of the components are not necessarily simply additive; the total may be more or less than the sum of the parts.

Consequently, although advances have been made in using analytical methods to determine the constituents of an odorous sample, only a human observer can indicate if an odour is present and the intensity of that odour, a situation which seems likely to persist for the foreseeable future.

Sensory methods are therefore used to quantify odours and WSL has adopted the dynamic dilution method, which is based on a measured flow of odorous sample being combined with a measured flow of clean air and presented to a panel of 6 or 8 people (18). The parameter determined by the panel is the dilution factor (d) which is the number of times a sample of gas has to be diluted by odour - free air before 50% of the panel of observers will just not detect an odour. Several dynamic dilution apparatuses have been constructed and used by WSL and a portable version, capable of providing dilutions in the range 25 to 250,000 is now commercially available (Table 5). It has been found that the optimum panel size is 6 - 8 and that 8 samples can be assessed by the panel each day by carrying out the assessments in two one hour sessions. The usual number of replicate samples is 2 and it has been estimated (18)

that with this number the 95% confidence limits for the dilution factor are -28% and +38%. In practice the method has been applied, virtually without exception, to the measurement of odour emissions (dilution factor X volume flow of odourous gas stream) from a wide range of processes by collecting samples in Tedlar bags and using the WSL mobile odour laboratory. The information obtained has enabled WSL to determine the actual efficiencies being achieved by abatement equipment and this has removed the necessity to rely on much more subjective assessments. The method will require further refinement, however, before it can be used regularly and reliably for quantifying the much weaker odours found in the ambient atmosphere.

WSL has also been studying and applying non-sensory methods of measuring odours with the object of providing more information on the general chemical nature of odours. A technique employing gas chromatography has been developed (19). Samples are collected using Tedlar bags (re the sensory measurements) and then passed through Tenax G-C traps in preparation for subsequent desorption onto the chromatography columns which separate the individual components of the gas. A variety of detectors, including a micro-wave plasma detector, a mass spectrometer and the human nose have been used to identify and characterise the components (see Table 5). The relative importance of particular odorants in a process have been established which is pertinent to the selection of optimum abatement equipment. It has also been possible to establish reasons for poor efficiency in existing equipment. In the longer term it may prove practicable, provided sufficient sensory and chromatographic data are compiled for a particular process, to correlate sensory data with some chemical property. This could lead to the development of a relatively simple instrumental monitor for such a process.

5. FUTURE DEVELOPMENTS

In addition to the remaining problems with selectivity, precision, reliability, etc which are associated with the methods described in the previous sections, there are also the limitations of representativeness imposed by extracting a sample from the ambient atmosphere and the high cost of in-situ continuous monitors. Extractive systems pose two main problems: (i) In most cases samples are collected at specific locations but the concentrations of the pollutants in question vary, often substantially, from place to place so that there is always the question of spatial representativeness of the results obtained (e.g. in an urban area

Table 5 Methods for the Measurement of Odours and Their Costs

1. Sensory measurements

Cost of portable dynamic dilution apparatus	:	£1600
Cost of ancillary sampling apparatus	:	£1000
Effort required for 8 samples (panel of 8)	:	7 man days

2. Instrumental measurements

Gas chromatograph, including integrator (at least 2 required)	:	£6000–8000
Flame ionisation detector	:	£1000
Flame photometric detector	:	£1000
Microwave plasma detector	:	£20,000
*Mass spectrometer	:	£75,000–£150,000
Effort required to analyse 8 samples	:	1–4 man weeks

---

* WSL made use of facilities at Queen Elizabeth College, London and the Physico-Chemical Measurements Unit of AERE, Harwell.

annual average SO_2 concentrations can vary by up to a factor of 2 within ½ – 1 km and in a busy street at any point in time the concentrations of CO can differ by a factor of up to 10 within 100m). (ii) There is the further problem with particulates of obtaining samples which are representative of the range of relevant particle sizes in the atmosphere because of the inertia of the larger particles and slippage through filters of the smaller particles. These problems can be partially overcome, in the case of the first by the greater use of mobile units incorporating in-situ instrumental techniques with adequate stability for "on the move" measurements, and in the second through improvements in the aerodynamic design of sampling head/filter assemblies and choice of appropriate filters. Also, remote sensing and other non-extractive techniques, despite their current high costs and complexity, will provide the means of overcoming these difficulties in some applications.

Perhaps the greatest limitation on the wider use of monitoring instruments is the high unit cost of the instruments; the capital outlay for SO_2, NO, NO_2, CO, THC and O_3 at one site could well exceed £20,000. Some of the non-extractive instruments, based

on tunable laser techniques, will be capable of monitoring more than one species and in due course could lead to a reduction in costs, especially if remote sensors can also reduce the number of locations at which monitors will be required. However, for more general applications the greatest scope for substantial reductions in the costs of monitors would seem to lie with microprocessors and detectors such as semi-conductors. Such developments would also lead to considerable improvements in, for example, reliability.

Central laboratory facilities, such as gas chromatography, mass spectroscopy and plasma detectors, are, of course, also continually being improved and these improvements, together with the introduction of newer techniques, such as proton induced X-Ray emission and ion chromatography, are making it possible to identify and determine the concentrations of an ever increasing number of chemical species at ever lower concentrations. For example, although smoke and total suspended particulates are still the most common measures of particulates in the ambient atmosphere there is now greater emphasis on dividing the particles into size ranges and on determining the chemical components within each range - the various combinations are almost limitless. Therefore, whilst it is very encouraging to know that the techniques are available and are being continually improved it is essential that the objectives of air quality monitoring are kept firmly in mind; it could be all too easy to allow the methods to dominate without due regard for just how useful the results would be. The question which is going to be asked more frequently in the future is not "can we measure" but "what should we measure" and against the inevitable background of limited resources that may well make decisions on monitoring programmes more difficult rather than easier.

6. REFERENCES

1. Reay, J.S.S. "The Philosophy of Monitoring" Phil.Trans. R.Soc. Lond. A 290, 609 - 623, 1979.

2. "National Survey of Air Pollution 1961-1971", Volume 1, HMSO, London, 1972.

3. Bailey, D.L.R., Barrett, C.F. and Cooper, I.C. "Levels of Smoke and Sulphur Dioxide at Remote Sites in the United Kimgdom (1969-1975)", Warren Spring Laboratory. Report LR 270(AP), Stevenage, 1978.

4. "The Investigation of Air Pollution : National Survey of Air Pollution". Warren Spring Laboratory, Stevenage; Annual Publication.

5. Keddie, A.W.C. and Weatherley, M-L.P.M. "Changing Patterns in Air Pollution and Fuel Consumption in the United Kingdom". In proceedings of Pollution Control Congress, London, 1973, Brintex Conferences Ltd.

6. "Digest of Environmental Pollution Statistics" No. 1. HMSO. London, 1978.

7. Keddie, A.W.C. "The Spatial and Temporal Distributions of Sulphur Dioxide and of Sulphates in Urban and Rural Atmospheres in the United Kingdom". In proceedings of International Symposium on Sulphur Emissions and the Environment, The Society of Chemical Industry, London, 1979.

8. "Smoke and Sulphur Dioxide Pollution Maps of the UK". Available for 1972/3 and 1975/6 from Department of the Environment Map Library, London.

9. McInnes, G. "Multi-element and Sulphate in Particulate Surveys: Monitoring Locations, Sampling and Analytical Methods and Preliminary Results Reporting System". Warren Spring Laboratory Report LR 247(AP), Stevenage, 1976.

10. McInnes, G. "Sulphate in Particulate Survey: Summary of Second Year's Results" Warren Spring Laboratory Report LR 288(AP), Stevenage, 1978.

11. McInnes, G. "Multi-element Survey: Analysis of the First Two Years Results" Warren Spring Laboratory Report LR 305(AP), Stevenage, 1979.

12. Turner, A.C. and Killick, C.M. "The Midlands Metals Survey: Concentrations of 15 Elements in the Air Around Factories in Birmingham and the Black Country" Parts 1 and 2. Warren Spring Laboratory Reports LR 303(AP) and LR 304(AP), Stevenage, 1979.

13. Clarke, A.J. and Spurr, G. "Routine Sulphur Dioxide Surveys Around Large Modern Power Stations I - Summary Paper "Atmos. Environ.10 265 - 268, 1976.

14. Apling, A.J., Potter, C.J. and Williams, M.L. "Air Pollution from Oxides of Nitorgen, Carbon Monoxide and Hydrocarbons". Warren Spring Laboratory Report LR 306(AR), Stevenage, 1979.

15. Apling, A.J. "Ambient Air Monitoring Using Instrumental Methods". Paper in preparation for the Institute of Mechanical Engineers Conference on Environmental Monitoring, Warwick, September 1979.

16. Keddie, A.W.C. "The Relative Importance of Motor Vehicles as a Source of Some of the More Common Atmospheric Pollutants" Paper presented to the NSCA Workshop on Pollution from Road Vehicles, University of Warwick, 9 - 11 April 1979.

17. Brice, K.A. and Derwent, R.G. "Emissions Inventory for Hydrocarbons in the United Kingdom" Atmos. Environ. 12 2045 - 2054, 1978.

18. Bedborough, D.R. and Trott, P.E. "The Sensory Measurement of Odours by Dynamic Dilution", Warren Spring Laboratory Report LR 299(AP), Stevenage, 1979.

19. Bailey, J.C. and Viney, N.J. "Analysis of Odours by Gas Chromatography and Allied Techniques", Warren Spring Laboratory Report LR 298(AP), Stevenage, 1979.

NATIONAL SOCIETY FOR CLEAN AIR

46th ANNUAL CONFERENCE
15-18 OCTOBER 1979
SCARBOROUGH

ADVANCED METHODS OF MONITORING AND MEASUREMENT

by

Dr. R.H. Varey,
Central Electricity Research Laboratories,
Leatherhead

and

David E. Green,
Central Electricity Generating Board,
N.E. Region, Scientific Services Department

National Society for Clean Air
136 North Street
Brighton BN1 1RG
England

INTRODUCTION

During the last decade a number of "advanced" measurement systems have been developed for measuring the concentration of pollutant gases and particles in the atmosphere, both at ground level and up aloft. This paper is in two parts. The first deals with instruments designed to track the rise and dispersion of industrial plumes and to measure the concentration of gaseous pollutants not only at the ground but also up in the atmosphere. The second deals with a survey carried out in the Selby area of Yorkshire into the occurrence of trace elements in fine particulates. This multi-element survey of solid particulate aerosols is being carried out in co-operation with and partly financed by the Selby District Council. For a number of years there has been increasing interest and concern about the concentration and effects of trace elements present in the atmosphere in particulate form. The objectives of this joint investigation are to determine the concentration of trace elements in solid particulate aerosols in the Selby District and to attempt to determine the contribution of Drax Power Station to this atmospheric burden.

REMOTE SENSING

The study of plume dispersion from industrial sources and the examination of the physical and chemical changes that emissions undergo in the atmosphere require the measurement of pollutant concentrations not only at ground level but also aloft. This can be done with conventional instruments mounted in aircraft but in general this is expensive and sometimes difficult, particularly in the vicinity of tall chimneys and in urban areas where flight paths are strictly controlled. Another approach is to use remote sensors, that is instruments located on the ground but able to measure pollutants large distances away.

One such instrument is a correlation spectrometer which can be used to measure SO_2 and NO_2. It operates by measuring the extent to which daylight, on its path to the earth's surface, is absorbed by pollutants in the atmosphere. The light is not absorbed uniformly across the spectrum, it occurs only at distinct wavelengths, and these differ according to the pollutant gas present in the atmosphere. This is illustrated in Figure 1 which shows the absorption spectrum of SO_2 in the ultraviolet. If the spectrum of skylight is examined and the depth of the absorption troughs is measured then, with the aid of calibration cells, the amount of SO_2 in the atmosphere can be deduced. What in fact is measured is the total amount of pollutant along the

line the light travels before entering the instrument. This is expressed as the product of concentration and distance and is called the 'burden'. Typically the instrument can measure burdens of SO_2 down to 10 μm which is equivalent, for example, to a concentration of 10 parts per million extending over a distance of 1m or 10 parts per billion over 1km.

The most useful way to operate a correlation spectrometer is to mount it in a vehicle and arrange the optics so that light is collected only from a line vertically above it. In this way the cross-wind, depth integrated profile of SO_2 is obtained as the vehicle traverses a power station plume whether the plume has reached ground level or not. The CERL vehicle is fitted with two spectrometers, one for SO_2 and one for NO_2. It also contains conventional instruments to measure ground level concentrations of SO_2, NO_2, NO, O_3 together with particulate concentrations and size distributions. It has a navigation system and a computer which is used to produce maps indicating the plume profile as the vehicle moves along the road. An example is shown in Figure 2. Here the burden of SO_2 and the ground level concentration are plotted to the right and left of the vehicle path and it can be seen that the plume has reached ground level on all traverses. The dispersion of the plume as it travels downwind is clearly marked and results of this sort are useful in the study of plume behaviour under a wide range of meteorological conditions. If the wind speed is known then profiles of this sort can be used to estimate the total flux of NO_2 and SO_2 in the plume and if they are measured at different distances downwind the rate at which various chemical reactions are proceeding can be deduced. Vehicles fitted out in this way can track plumes over large distances, well beyond the range at which they are visible to the naked eye. Figure 3 shows the plume from Fawley Power Station, near Southampton, followed as far as Guildford, a result due to the fine sensitivity of the instrument rather than the concentration of the plume. Larger plumes, the Sudbury smelter in Canada for example, have been tracked out to distances of 1000 km and more.

In spite of their success correlation spectrometers have some drawbacks. In the first place they can operate only in daylight and since a fairly high light level is required to obtain good sensitivity, in winter months their use is limited to only a few hours either side of midday. They provide results for total burden but give no direct indication of the spatial distribution of pollutants in the vertical. Finally, because of interference from other atmospheric constituents, principally ozone, it is sometimes difficult to obtain quantitative results.

To overcome these difficulties a new type of instrument has been developed which instead of using skylight for its operation has its own source of light. This is provided by a laser, the light from which is fired into the atmosphere and the small amount scattered back to the ground by aerosols is collected in a telescope and measured. This is illustrated in Figure 4. Light from the laser is emitted in short pulses and by measuring the time interval between firing and receiving light back at the telescope one can calculate the range of the particular volume of aerosol causing the backscatter. Of course the timing has to be accurate since it takes light only about 3 millionths of a second to travel a kilometre. By carefully controlling the direction in which the laser is fired and measuring the time intervals one can pinpoint areas in the atmosphere for examination. It is this facility which gives this type of instrument its name, LIDAR. This is an acronym for Light Detection and Ranging, similar to RADAR but in lidar, light is used instead of radio waves. A laser is used because it provides a very short intense pulse of monochromatic light which means that nearly all the sunlight entering the telescope can be eliminated by optical filters. This is important because although the laser pulse is very intense the amount of light backscattered by the atmosphere is very small and would be swamped by skylight during daytime operation. A further advantage of a laser is that the beam can easily be made very narrow, typically it has a diameter range of only one metre at a range of a kilometre.

Two lidars have been developed at C.E.R.L. One is used to measure plume rise and dispersion and the other to determine the distribution of SO_2 and NO_2 in a manner similar to that of correlation spectroscopy. For dispersion studies the laser is simply fired at the plume a number of times at slightly different angles of elevation so that a complete cross section is obtained. This is done at different distances from the stack so the plume trajectory and the evolution of its cross-section can be studied. The C.E.R.L. instrument can measure plumes as far away as 10 km and has sufficient sensitivity under the normal range of meteorological conditions to obtain cross-sections of power station plumes up to distances of 5 km or so from the stack. Figure 5 shows some results obtained at a location along the Thames. The diagram shows the plumes which were scanned and the photograph shows the actual results obtained.

An interesting feature of this type of lidar is that it can be used to measure the thickness of the atmospheric boundary layer, a central factor determining the dispersion of a plume. At the top of the boundary layer there is often a sharp drop in the

aerosol concentration so that as a laser beam travels upwards there is a marked decrease in the backscattered signal when it emerges above the mixing layer. Figure 6 shows the results obtained from a lidar firing vertically upwards over a period of about twenty minutes. Each successive shot is displaced slightly to the right so the photographs represent the vertical aerosol distribution above the lidar as a function of time. At the beginning of the period there is a well defined stably stratified structure and as time progresses this begins to break up when convection develops as the ground is warmed by the sun.

The second type of lidar operates in a manner rather closer to that of correlation spectrometers in that it measures the absorption of light by a single pollutant gas of interest. Absorption occurs along the path of the laser pulse out into the atmosphere and back again to the telescope. In fact, a special laser is used which can be tuned to produce pulses at different wavelengths. One pulse is fired at a wavelength corresponding to a maximum in the absorption curve, Figure 1, and the next at an adjacent minimum. The difference between the two backscattered signals is used to calculate the concentration of the pollutant along the line the light has travelled. Because the method depends upon the difference between two signals it is called differential lidar or DIAL for short. Light is backscattered from all points along the path of the pulse and so by examining the signal difference as a function of time the spatial distribution of the pollutant can be determined.

A typical set of backscatter records is shown in Figure 7. After a sharp initial rise, due to characteristics of the optical system, the signal decreases rapidly with range, due partly to attenuation in the atmosphere and partly to an inverse square law in the collection of the backscattered light. The important feature is the peak in the curves at a range of about 325m. This is caused by enhanced backscatter from the aerosol content of a power station plume. Until the laser pulses reach the plume their backscattered intensity is the same, but once inside the plume those pulses at the strongly absorbed SO_2 wavelength immediately become less intense than those at a minimum in the absorption spectrum. The difference increases as more of the plume is penetrated and then remains constant on the far side.

In practice it is not sufficient to measure just two pulses. In general they are so weak that several hundred have to be averaged to select the signal of interest from the noise. Figure 7 is the average of two hundred pulses each at maximum and minimum absorption. At a typical pulse rate of 20 Hz this

takes a matter of seconds but a computer is required to record and analyse the data. This is housed in a lorry with the laser and telescope, Figure 8. Mounted in this way DIAL can be used for mobile surveys in the same way as correlation spectrometers but with the advantages of providing spatial resolution as opposed to integrated vertical burden, limitation due to changes in the sunlight spectrum are removed, and it is much less prone to interference from other species. The system shown in Figure 8 operates in the ultraviolet and visible region of the spectrum and is used to measure SO_2, NO_2 and O_3 with a sensitivity of about 10 ppb at a range of one kilometre and spatial resolution of 150 m. Other systems are being developed which operate in the infra-red and can be used to measure a large number of other species such as CO_2, HCl, CH4 NO.

MULTI-ELEMENT SURVEY IN THE SELBY DISTRICT

For a number of years there has been increasing interest and concern about the concentration and effects of trace elements present in the atmosphere in fine particulate form. One area of especial concern has been in the field of particulate emissions from power stations. The stipulated high efficiency of the electrostatic precipitation plant used on modern power stations reduces the emissions to a minimum. However, because of the substantial tonnages of fuel that are burnt by the C.E.G.B. the quantity of emission per year is considerable. Furthermore it is the finer particles that have a greater tendency to pass through the elctrostatic precipitators and these particles may contain higher concentration of trace elements.

In 1975 the Selby District Council commissioned the U.K.A.E.A. (Harwell) to carry out a survey of the concentration of particulate trace elements in the Selby District Council area. This area contains two 2000 MW power stations at Drax and Eggborough and has the Ferrybridge complex of 2,300 MW on its western border. In addition the area was going to be further industrialised with a further 2000 MW of power plant at Drax and the large Selby coalfield.

Discussions took place between the Chief Environmental Health Officer of the Selby District Council and the C.E.G.B. and agreement was reached that a joint investigation should be carried out by the two bodies. In the first year the results obtained by each body would be exchanged and in subsequent years the work would be undertaken by the C.E.G.B. and the Selby District Council would make a financial contribution to the cost of the work and receive in return the report of the work carried out.

Measurements of this type were already being carried out in a number of locations within Great Britain by the U.K.A.E.A. and others and thus it was decided that the survey equipment and the methods of analysis of the samples should be identical with those used by the U.K.A.E.A. thus making the results directly comparable.

The four sites chosen for the initial Selby survey were selected by the Selby Authority, (Selby, Kellington, Sherburn, Tadcaster), in conjunction with the U.K.A.E,A. and were situated on the western border of the District Council area thus giving the inputs from West Yorkshire carried by the prevailing winds. The four C.E.G.B. sites, (Asselby, Camblesforth, Cliffe and Howden), were chosen to cover the eastern side of the area to be downwind of the C.E.G.B. power stations for the prevailing wind (Figure 9). In addition each C.E.G.B. site housed existing sulphur dioxide measuring equipment. In the second and subsequent years of the survey one of the initial Selby sites has been added to the C.E.G.B. sites so that measurements are now being made by C.E.G.B. at five sites.

In the C.E.G.B. survey four types of sampling equipment were deployed as follows:-

(i) Air Concentration Sampler
This samples the atmospheric particulates by filtering air on a 5.5cm Whatman 40 filter paper at the rate of approximately $50m^3$ per week. The inlet nozzle faces downwards and under the operating conditions employed it has an upper practical cut-off diameter for the sampling of atmospheric particulates of 5 - 6 um aerodynamic diameter.

(ii) Total Deposition Sampler
This sampler consisted of a 15cm diameter funnel, screened with a 0.5mm mesh terylene gauge and a 4.5 litre polythene bottle for collecting the sample.

(iii) Switched Air Concentration Sampler
This sampler was identical with that described in (i) above except that the pump drawing air through the sample head was controlled by the direction vane of a Munro anemometer. This actuates the pump when the wind was blowing from the direction of Drax Power Station. The arc of wind directions covered was 30^0 and the centre of the sector was offset to take account of the change of wind direction with height.

(iv) Synthetic Grass Sampler
A synthetic grass sample - Astroturf - of $0.08m^2$ area was suspended at ground level over a plastic bowl which had been inserted into the soil. At the end of each month the 'turf' was washed and the sample collected in the bowl was analysed

in the same way as the total deposition sample. This sampler was discontinued after one year because the results obtained from it and the total deposition sampler were not significantly different.

The samplers described in (i) and (ii) are identical with those used by the U.K.A.E.A. The samples obtained were analysed at quarterly intervals for thirty-seven elements by the U.K.A.E.A. by three methods. The majority of analyses were carried out using neutron activation analysis followed by gamma ray spectrometry. The determinations of lead and nickel on solid samples was carried out by x-ray diffraction. The determinations of lead and copper were made by colorimetry and those of nickel and cadmium by atomic absorption on the aqueous fractions. A detailed account of these methods of analysis and the reproducibility obtainable is given by Cawse et al (A.E.R.E. R7134). Essentially the relative standard deviation is shown to be approximately 15% for replicate samples of airborne dust and 25% for rainwater.

The total mass of particulates collected measured on a monthly basis varied between 10 and 50ug per Kg of air with a mean concentration of 30µg per Kg of air. The tendency noted in previous surveys of this type for the concentration of atmospheric particulates to be highest in the winter months was not shown by this survey. This may be the result of the unusual weather conditions experienced during the period of measurement.

The results for a three months period when the Selby and C.E.G.B. surveys were concurrent are given in Tables 1.

Examination of the results in these tables indicates that the approximate order of air cleanliness (cleanest to dirtiest) in respect of the thirty elements is Cliffe, Camblesforth, Asselby, Howden, Tadcaster, Sherburn, Kellington and Selby. This result has been obtained by ranking each site for each element in terms of concentration and summing the rankings. The order obtained is approximately in proportion to the proximity and number of adjacent buildings.

The Department of the Environment have carried out a similar survey at Windermere over a considerable number of years. The site is considered to be a clean one and situated well away from any industrial sources. One methoc of assessing the effect of industrial sources on the atmospheric particulate concentration is to compare the results obtained for the sites in question,

with those obtained at Windermere. The results of this comparison are given in Table 2. It will be seen that the results for the C.E.G.B. sites are less than those for the initial Selby sites, and additionally that the directional sampler at Cliffe gave values greater than those for the other C.E.G.B. sites. The concentration of zinc in the atmospheric samples at Camblesforth Cliffe and Howden was higher than would have been expected from the other data. The cause is being investigated but was probably due to oxidation of zinc on a part of the support structure.

Examination of the quarterly load weighted wind rose data for the four C.E.G.B. sites indicated that there were considerable differences in the rankings for Cliffe, Asselby and Howden, but no significant differences for Camblesforth. Comparison of the rankings with elemental air concentrations agreed for only two elements at Asselby (nickel and zinc), one element at Cliffe (silver) and no elements at Howden. Nine elements agreed for the Cliffe directional sampler. This suggests in a qualitative way that the contribution from Drax to the elemental air concentrations is not significant and that the contribution becomes significant only when the air concentration is effectively increased by the directional sampler. This fact was confirmed by the total deposition samples which gave no significant correlations with the load weighted wind rose.

A parameter that may be derived from the elemental air concentration and from the total deposition is the "washout" factor which is defined by

$$\text{Washout Factor} = \frac{\text{Concentration in rain} \quad (\mu g/Kg)}{\text{Concentration in air} \quad (ng/Kg)}$$

The concentration in rain is measured as the total deposition which is a summation of the material scavenged by the rain and by the deposition on the collecting surface. The most efficient part of the rain scavenging process will occur at the precipitation altitude of a few kilometres, since once formed and falling, collisions between rain drops and atmospheric particles leading to capture of the particles will be a relatively inefficient process. Thus in general terms high washout factors are associated with small particles well dispersed at high altitudes. In long periods of dry weather it is possible that deposition may be the most significant input to the total deposition sampler. Examination of Figure 10 which compares the washout factors for the two samplers at Cliffe indicates that for all elements the directional sampler gives lower washout factors. Lower washout factors are generally associated with local sources

which again may indicate that this sampler is sampling a local source.

One approach to the identification of sources to distinguish between natural and anthropogenic origins is to examine the relative enrichment of the elements compared with their relative abundances in soil. No information is available for the concentration of trace elements in the soil in the Selby District and thus the most up-to-date and comprehensive listing of trace elements in the earth's crust has been used.

The formula used for the calculation of elemental enrichment is

$$\text{Enrichment Factor} = \frac{(Cx/Csc)\ \text{atmosphere}}{(Cx/Csc)\ \text{earth's crust}}$$

where Cx is the concentration of the element x and Csc is the concentration of scandium. Throughout this work Scandium has been used as the normalising element since it is present in all samples at a concentration that is accurately measurable and it is believed to be an element which is conservative and predominantly of natural origin. The enrichment factors are given in Table 3. The data confirms the observation made by other authors (Dams 1974, Paciga 1976) that the enrichment factors measured throughout the northern hemisphere are quite consistent. Comparison of enrichment factors with the elemental periodic classification (Figure 11) is particularly striking. Elements in the first two groups and those forming refractory oxides have low enrichment factors. Elements in the transition groups except for the copper and zinc groups have low enrichment factors. Elements in the copper and zinc groups and all the remaining elements show high enrichment factors. This latter group are those elements which form volatile compounds during the combustion process, and it is probable that these elements are present in the atmosphere due to man's activities. Since the atmospheric sampling procedure is biased towards small particles, which in the combustion process have the largest surface area available for condensation of volatiles, this data supports the general view (Davison 1974) that the enrichment of this group of elements in the atmospheric particulates is due to a volatilisation, condensation mechanism.

Whatever criterion is used for the assessment of the data obtained in this survey none of the concentrations of trace elements measured in the atmosphere or in the total deposition samples appear to constitute a health hazard when compared with published standards. The element whose concentration approaches nearest to that of any of the air quality standards is lead with a

measured concentration between 100 - 200 nanogram/Kg. This can be compared with the U.S. ambient air quality standard of 1000 ng/Kg.

This programme of work is continuing and being extended, in collaboration with Selby District Council. Directional samplers are being placed up-wind and down-wind of a 2000 MW station each sampler being computer controlled from one central meteorological station such that they sample the same parcel of air as it passes through the area. In this way it is hoped that a further assessment of the contributions of a 2000 MW power station to the atmospheric particulate concentrations in a rural area may be made.

ACKNOWLEDGEMENTS

This paper is published with the permission of the Director General of North Eastern Region and Research Department of the Central Electricity Generating Board. Acknowledgement is also made to the Selby District Council and their Chief Environmental Health Officer, Mr. N.H. Parkinson, for their co-operation in this work.

FURTHER INFORMATION

Hamilton P.M., Varey R.H. and Millan M.M.	1978	Remote sensing of Sulphur Dioxide, Atmos. Envir., 12, 127-133
Varey R.H., Ellis R.M. Hamilton P.M., Moore D.J., and Sutton S.		Plume Dispersion and SO_2 Flux Measurements at Drax Power Station, England, Correlation Spectroscopy Conference, Toronto, Canada, June 1977.
Hamilton P.M.	1969	The Application of a Pulsed-Light Rangefinder (Lidar) to the Study of Chimney Plumes, Phil. Trans. Roy. Soc. London A 265 153-172.
Adrain R.S., Brassington D.J., Sutton S. and Varey R.H.	1979	The Measurement of SO_2 in Power Station Plumes with Differential Lidar, Opt. Quant. Electron. 11, 253-264.
Sutton S.	1979	An Appraisal of a Prototype Differential Lidar, C.E.G.B. Report RD/L/N 170/78.
Cawse and Peirson		An Analytical Study of Trace Elements in the Atmospheric Environment A.E.R.E. R7134.
Dams	1974	Study of National Air Pollution by Combustion, Part 1, Inorganic Composition of Air-borne Particulate Matter, NCSLV Belgium 1974.
Paciga and Jervis		Environmental Science and Technology Vol. 10 No. 12 November 1976.
Davison, Natusch, Wallace and Evans		Environmental Science and Technology Vol. 8 No. 13, December 1974.
Wilcox, Kleitz and Duncan		W.H.O. International Symposium, June 1974.

ELEMENT	SELBY	KELLINGTON	SHERBURN	TADCASTER	ASSELBY	CAMBLESFORTH	CLIFFE	HOWDEN
Aluminium	1030	710	720	470	580	1000	640	1500
Antimony	4.8	5.6	5.0	4.0	3.1	3.9	2.9	2.9
Arsenic	11	13	10	11	6.4	8.8	6.5	5.7
Bromine	75	74	55	58	32	43	30	26
Cadmium	3.9	6.6	5.9	2.4	3.3	4.2	4.4	<1.5
Caesium	0.32	0.40	0.32	0.31	0.15	0.32	0.20	0.17
Calcium	2000	1700	2500	860	1200	1700	900	2800
Cerium	1.2	1.1	0.94	0.68	0.81	0.70	0.49	1.1
Chlorine	6100	5900	4500	3800	2500	2800	2800	2700
Chromium	12	12	8.6	6.9	6.3	6.5	4.8	5.9
Cobalt	0.66	0.75	0.58	0.42	0.48	0.49	0.36	0.43
Copper	83	56	67	50	38	37	35	39
Europium	0.033	0.030	0.023	0.013	0.024	0.024	0.013	0.031
Indium	0.22	0.23	0.15	0.24	0.13	0.11	0.15	0.21
Iodine	7.3	11	3.2	5.8	<1.0	< 2.0	2.8	4.0
Iron	920	900	780	500	630	740	440	770
Lead	260	160	160	120	110	130	120	120
Magnesium	250	<170	630	440	<100	< 200	<90	610
Manganese	39	34	36	31	26	30	17	42
Mercury	0.11	0.22	< 0.10	0.097	< 0.15	< 0.13	<0.087	0.13
Molybdenum	<1.6	<1.2	< 1.2	< 2.4	<0.8	1.2	<0.8	< 0.6
Nickel	7.0	5.8	4.2	14	11	6.5	4.6	3.7
Potassium	1200	780	950	690	1100	< 300	480	< 200
Rubidium	3.2	3.1	3.6	2.2	2.1	4.0	1.6	1.7
Samarium	0.10	0.085	0.072	0.051	0.07	0.084	0.045	0.10
Scandium	0.25	0.22	0.19	0.12	0.19	0.21	0.12	0.24
Selenium	4.1	5.7	3.8	3.2	2.2	3.2	2.2	1.5
Silver	0.49	0.52	0.44	0.32	0.32	0.34	0.29	0.34
Sodium	1700	1500	1500	1500	1000	1300	1100	990
Thorium	0.19	0.19	0.13	0.083	0.17	0.17	0.092	0.21
Titanium	170	120	96	97	78	80	33	120
Vanadium	20	18	17	13	7.8	10	13	11
Zinc	130	150	140	100	290	230	140	160

TABLE 1 - AIR CONCENTRATION FOR ALL SITES FOR MARCH/APRIL/MAY 1976

ELEMENT	ASSELBY	CAMBLESFORTH	CLIFFE	CLIFFE DIRECTIONAL	HOWDEN	SELBY	KELLINGTON	SHERBURN	TADCASTER	
Aluminium	2.9	2.8	2.4	3.4	4.2	5.2	4.3	4.1	2.8	Al
Antimony	1.9	2.1	1.8	3.4	1.8	3.3	3.4	3.6	2.5	Sb
Arsenic	1.9	2.3	1.9	3.0	1.8	3.5	4.0	3.2	2.9	As
Bromine	1.1	2.1	1.5	3.2	1.3	4.3	4.0	3.1	2.8	Br
Caesium	1.0	1.6	1.2	1.8	0.97	2.5	2.8	2.5	1.9	Cs
Calcium	1.8	2.1	1.9	3.0	4.2	4.8	5.0	6.2	2.4	Ca
Cerium	2.4	2.3	2.0	2.8	2.9	3.6	3.4	3.2	2.4	Ce
Chlorine	1.6	1.8	1.2	3.0	1.7	2.9	3.0	2.2	1.9	Cl
Chromium	2.4	2.6	2.2	3.0	2.2	4.3	4.1	3.3	2.8	Cr
Cobalt	1.9	2.1	2.1	4.2	1.7	1.6	1.6	1.4	1.1	Co
Copper	1.7	1.7	1.5	6.1	2.0	3.6	3.1	2.5	1.8	Cu
Europium	2.9	3.0	2.0	3.4	3.4	4.3	4.1	3.3	2.6	Eu
Gold	1.0	0.86	1.0	3.7	-	-	-	-	-	Au
Indium	3.0	3.2	2.7	2.5	3.9	2.1	2.7	2.2	2.2	In
Iron	3.2	2.5	2.3	3.8	2.9	3.5	3.3	3.1	2.3	Fe
Lanthanum	1.1	1.4	1.1	2.1	1.3	-	-	-	-	La
Lead	2.2	2.6	2.1	4.3	2.2	4.5	3.6	3.7	3.1	Pb
Magnesium	1.5	-	1.3	1.9	2.7	1.1	0.70	1.3	0.55	Mg
Manganese	2.2	2.3	1.9	4.4	3.2	2.8	2.7	2.6	2.2	Mn
Nickel	2.1	1.8	1.6	7.3	1.6	2.1	2.2	2.0	2.5	Ni
Potassium	1.2	-	0.67	1.8	1.7	1.1	0.89	1.0	0.88	K
Samarium	2.9	2.6	2.1	2.1	3.3	3.9	3.5	3.0	2.3	Sm
Scandium	3.0	2.6	2.1	3.5	3.3	4.6	4.5	3.9	3.0	Sc
Selenium	1.0	1.4	1.0	2.2	0.88	2.2	3.0	2.2	1.8	Se
Silver	0.94	1.2	1.1	3.3	1.0	1.7	2.2	1.7	2.0	Ag
Sodium	0.88	1.1	0.77	1.1	0.77	1.3	1.2	1.2	1.1	Na
Thorium	3.7	3.3	2.1	4.4	4.4	4.7	4.5	3.7	2.7	Th
Vanadium	1.3	1.5	1.5	2.0	1.5	2.1	2.1	2.0	1.6	V
Zinc	2.7	8.5	6.0	13	4.8	2.6	2.9	2.7	2.0	Zn

TABLE 2 - ELEMENTAL AIR CONCENTRATION RATIOS COMPARED WITH WINDERMERE

ELEMENT	ENRICHMENT FACTOR				
	ASSELBY	CAMBLESFORTH	CLIFFE	CLIFFE DIRECTIONAL	HOWDEN
Aluminium	0.94	1.0	1.1	0.93	1.2
Antimony	2500	3000	3200	3700	2100
Arsenic	490	700	730	690	430
Bromine	1600	3600	3200	4100	1800
Cadmium	2000	4000	4700	< 1400	-
Caesium	7.9	14	13	12	6.8
Calcium	3.5	4.7	5.4	5.0	7.4
Cerium	1.6	1.7	1.8	1.6	1.7
Chlorine	3100	3900	3400	1400	2100
Chromium	7.3	9.0	9.2	7.6	5.8
Cobalt	2.1	2.7	3.5	4.1	1.8
Copper	73	83	90	220	76
Europium	2.5	2.9	3.4	2.5	2.6
Gold	230	220	320	720	< 140
Indium	220	270	280	160	260
Iron	1.9	1.7	2.0	2.0	1.6
Lanthanum	3.3	4.6	4.6	5.4	3.5
Lead	1400	1800	1800	2300	1200
Magnesium	2.5	< 2.5	3.1	2.7	3.9
Manganese	4.1	4.8	5.0	6.9	5.3
Nickel	12	11	12	34	7.6
Potassium	4.1	< 3.0	3.4	5.5	5.4
Samarium	1.5	1.5	1.6	0.93	1.6
Scandium	1	1	1	1	1
Selenium	5100	7500	7300	9300	3900
Silver	520	730	830	1500	400
Sodium	3.4	4.9	4.5	3.8	2.3
Thorium	2.9	2.8	2.3	2.9	3.0
Vanadium	9.0	12	15	12	9.0
Zinc	310	160	960	1300	490

TABLE 3 - ELEMENTAL ENRICHMENT FACTORS

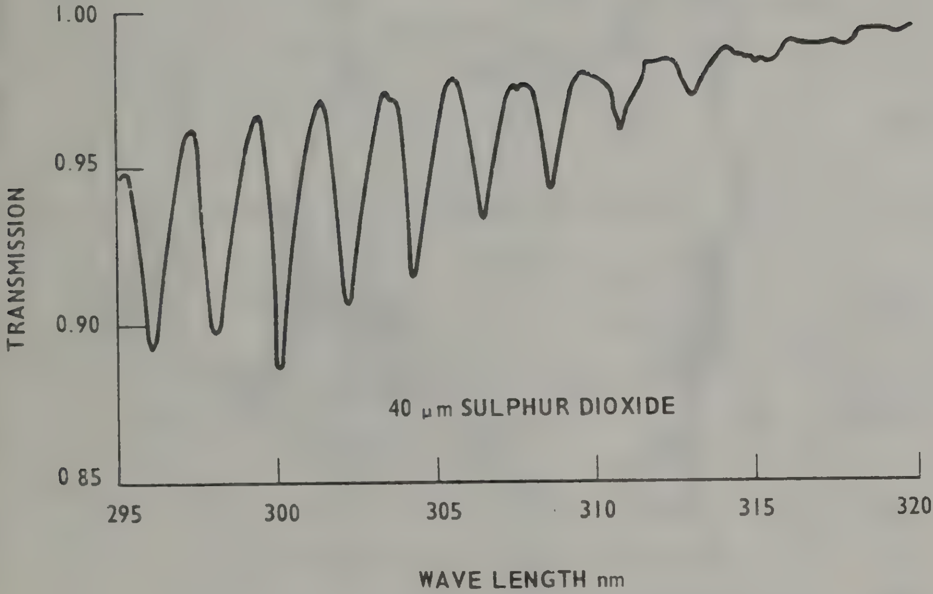


FIG. 1 ABSORPTION SPECTRUM OF SO_2

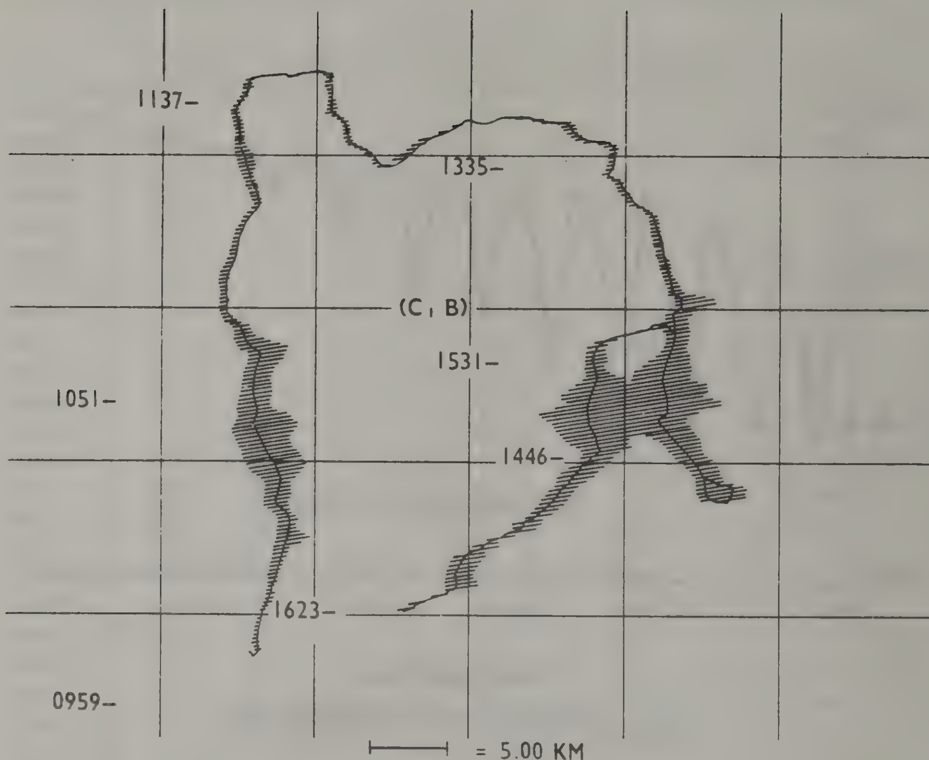


FIG. 2 EXAMPLE OF RESULTS OBTAINED WITH A POLLUTION SURVEY VEHICLE, SO_2 BURDEN PLOTTED TO THE RIGHT AND GROUND LEVEL CONCENTRATION TO THE LEFT

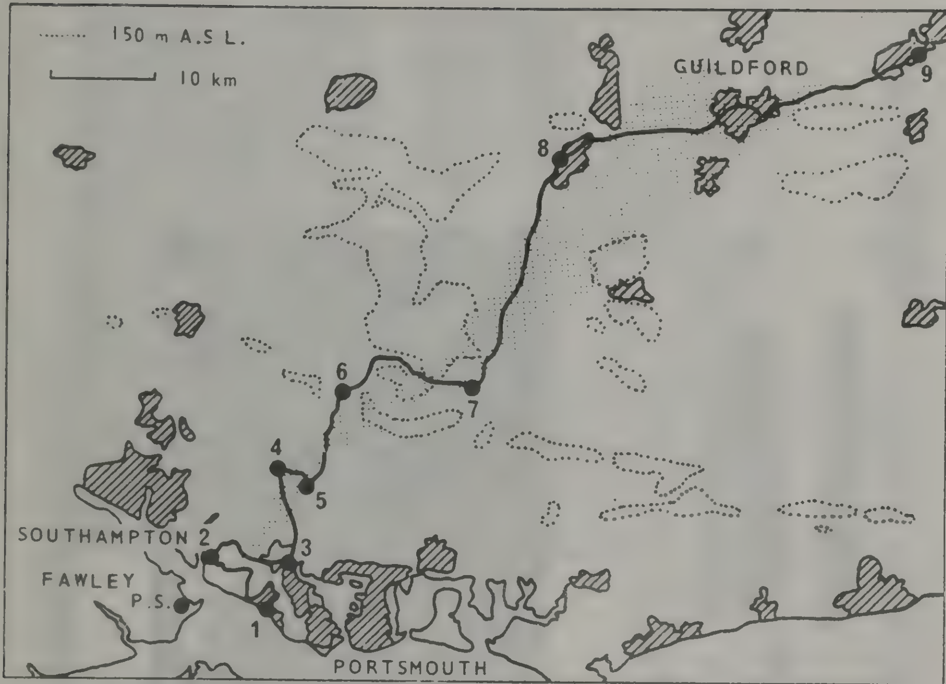


FIG. 3 MAP OF PLUME SURVEY 29 MAY 1973

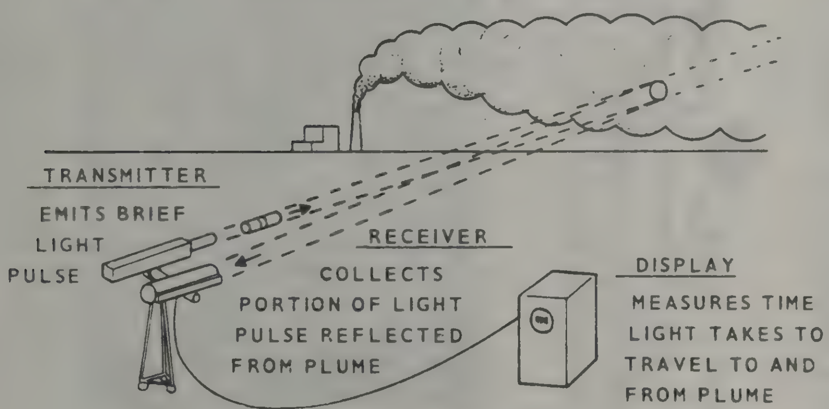


FIG. 4 THE PRINCIPLE OF LIDAR

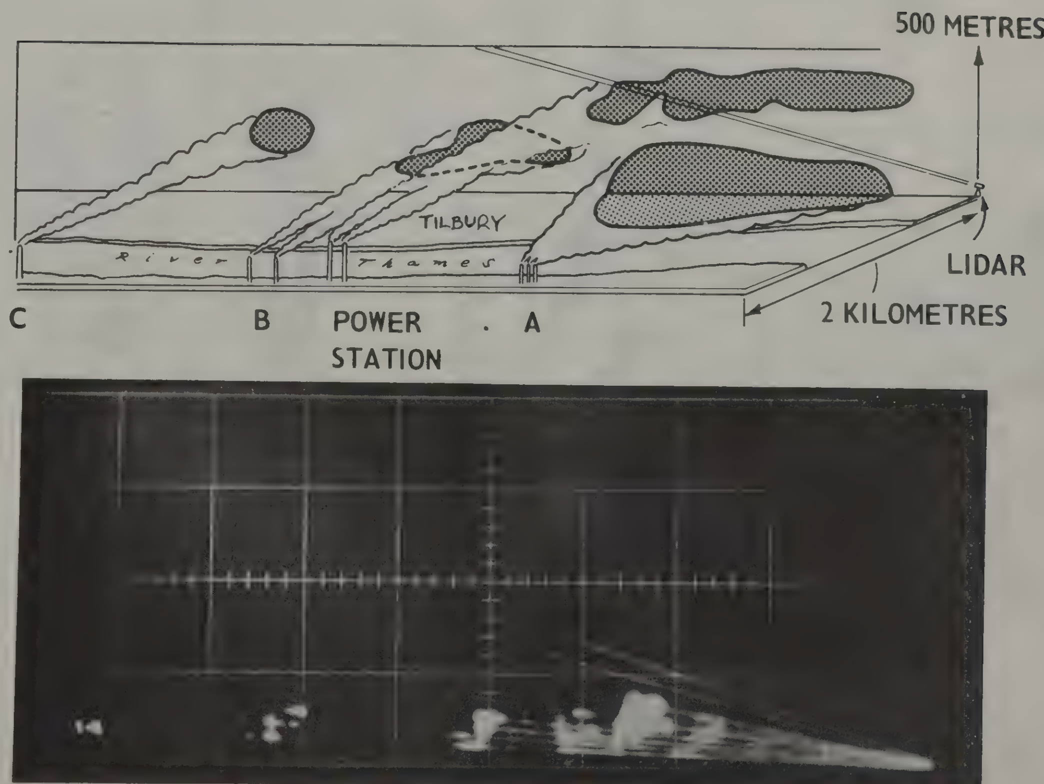


FIG. 5 LIDAR SCANS OF THAMESIDE PLUMES

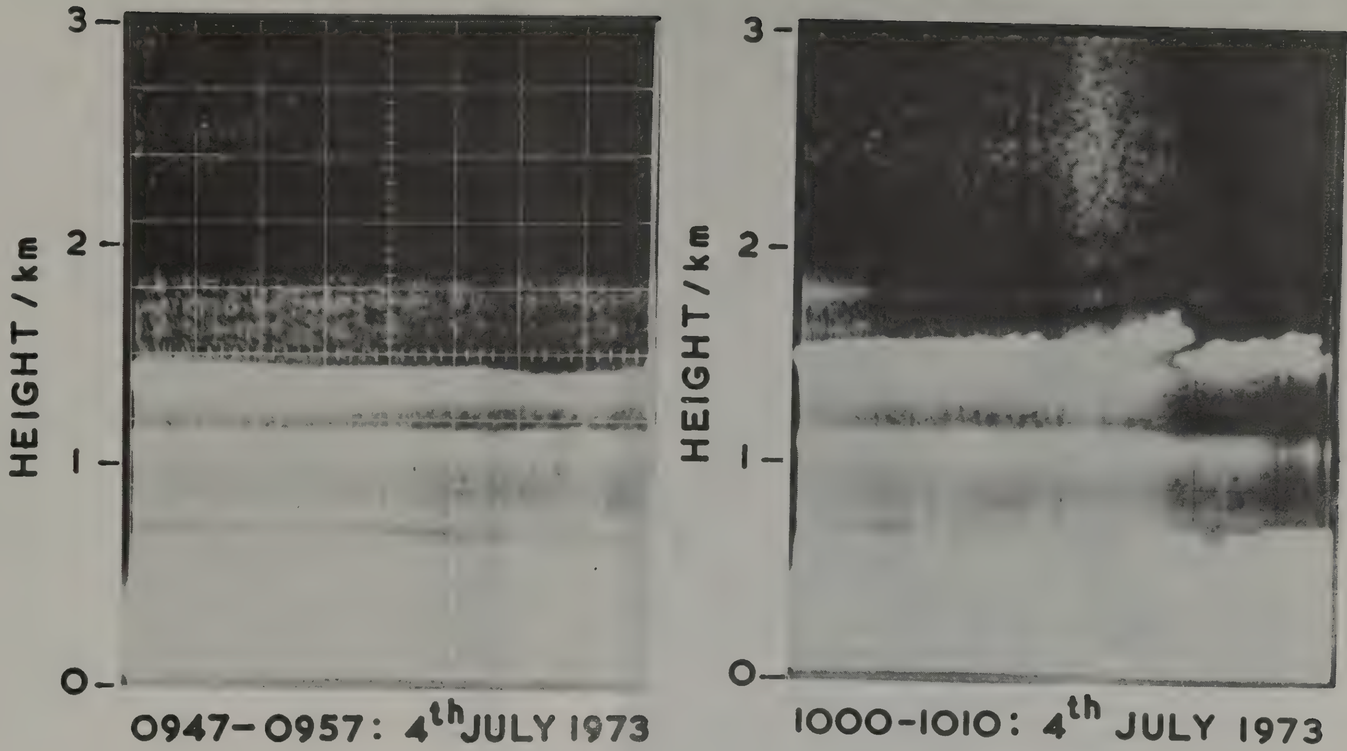


FIG. 6 LIDAR PROFILES OF VERTICAL DISTRIBUTION OF ATMOSPHERIC AEROSOLS IN THE BOUNDARY LAYER

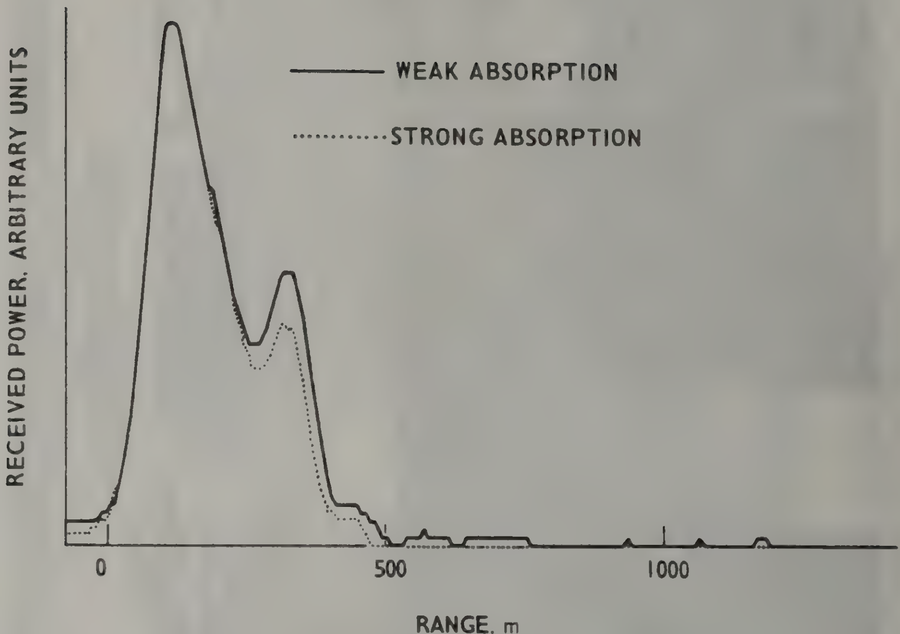


FIG. 7 BACKSCATTERED SIGNALS AT WAVE LENGTHS OF STRONG AND WEAK SO_2 ABSORPTION

FIG. 8 DIFFERENTIAL LIDAR VEHICLE

NATIONAL SOCIETY FOR CLEAN AIR

46th ANNUAL CONFERENCE
15-18 OCTOBER 1979
SCARBOROUGH

FACTORS AFFECTING ENVIRONMENTAL SOUND PROPAGATION

by

Harjodh S. Gill and Professor J.B. Large
Institute of Sound and Vibration Research,
University of Southampton

National Society for Clean Air
136 North Street
Brighton BN1 1RG
England

1. INTRODUCTION

In recent years, environmental noise has assumed increased importance in many countries and there is no doubt that transportation noise is the major source of noise annoyance in the world today. The most serious offenders are road traffic, which has grown rapidly over the last twenty years, and air traffic which has also increased significantly since the introduction of the commercial jet airliner in the late 1950's. This growth has led to increases in noise levels in relatively quiet environments, alongside motorways and in the vicinity of airports to a point where a significant percentage of the population is disturbed. Also, with the advent of increased railway traffic and speed, in many countries, railway noise may also be considered as an intruder in the noise environment. There are also other noise sources, besides the transportation noise sources, which can be equally disturbing to the community living within the near vicinity of a noisy source(s), for example: a large industrial complex; cooling towers for power plants; quarry blasting; and civil engineering construction sites.

With the introduction of many national and international emission and immission standards and regulations throughout the world, it is becoming increasingly important to predict or measure more accurately the sound levels from very many intense noise sources. Thus, if the noise levels are found to be excessive then it becomes necessary to instigate methods of controlling the impact of noise on the community.

The propagation of sound in the atmosphere occurs as a result of transmission of acoustical energy to point of observation, and so it is expected to be controlled by very complex and varied processes; and by far the most important factor in this propagation other than the characteristics of source of noise, is the weather, or technically speaking, the microclimate of the first 100 metres or so above the ground. Since the lower atmosphere is constantly in motion, and as the noise propagation depends on the transfer of energy from one molecule to another, so the received noise levels fluctuate. The longer the transmission path through the atmosphere, the less certain the average amplitude and the greater the fluctuations in the received sound.

Often in outdoor sound propagation problems, the receiver is close to ground, but in certain cases it is at a considerable height above the ground. The majority of the transportation noise sources are close to the ground and the noise travels through the lower layers of the atmosphere; aircraft in flight are, of course,

the exception. The noise originating from aircraft in flight usually travels a considerable distance through the atmosphere. The sound propagation is further affected by the interposition of any obstacles between the source and the receiver or any reflecting surfaces, and also by the ground cover.

In some cases, it may be possible that large sums of money spent on either noise control or law suits can depend on the location of a noise contour, for example, around an airport, motorway or an industrial complex. Indeed, this in turn requires a better understanding of the physical phenomena involved in outdoor sound propagation.

The purpose of this paper therefore, is to outline the physical phenomena that are associated with the propagation of sound outdoors and to present their theoretical basis together with some measured data. In addition, the effects of source characteristics and the physical environment along the propagation path are outlined. Furthermore, the simplified approach in overcoming the practical difficulties in predicting environmental noise is presented and exemplified with consideration of air and road traffic noise sources.

2.0 FACTORS INFLUENCING OUTDOOR SOUND PROPAGATION

Outdoor sound propagation mechanisms are very complex in nature and it includes the phenomena of refraction and geometric spreading, air and surface absorption, and scattering, reflection, and diffraction. All of these are important and assumed to be independent of one another, although they may be interdependent. Indeed, the main problem in studies of environmental noise propagation is that of determining which mechanisms are dominant in any particular situation. Figures 1 and 2 give some indication on important mechanisms controlling the outdoor sound propagation from the sources on or near the ground (e.g. traffic) and for sources in the air (e.g. aircraft in flight) respectively.

In this section, a brief description of the most important factors affecting the sound propagation is given together with the indication of the likely effect on the overall received noise levels.

2.1 GEOMETRIC SPREADING

Geometric spreading is always associated with the spreading of sound energy in space as a result of the expansion of the wave fronts. It always causes an attenuation in sound levels by a

certain amount when the propagation distance is changed by a fixed ratio. This attenuation value differs for an idealised point and a line source, over the same distance. The point source is the most common one, and it produces a spherical sound field, that is, source radiating equally in all directions in free space. A line source is exemplified by a busy highway in which sound is being radiated from many vehicles over an extended distance. Sound from such a line source will radiate with a cylindrical pattern.

The associated theoretical attenuation rates for a point and a line source are 6 and 3 dB per doubling of distance respectively.

Geometric spreading is generally considered to be independent of frequency and has a major effect in all situations of sound propagation.

2.2 EFFECT OF ATMOSPHERIC ABSORPTION

Because air is not a perfectly elastic medium, during successive compressions and rarefactions several complex irreversible processes occur, all of which are frequency dependent. Sound absorption in quiet, isotropic air is caused by two processes. The first may be thought of as combining the effects of viscosity and the conduction of heat during a single pressure cycle. The attenuation due to this so-called "classical" absorption can be conveniently calculated by the use of Kirchoff's Laws.

For air at 20^{o}C this has been given as

$$\alpha \simeq 1.2 \times 10^{-10} f^{2} \mathrm{dB/m} \qquad (1)$$

where α is the attenuation due to "classical" absorption, and f is the frequency in Hz.

Thus, at a frequency of 1000 Hz an attenuation of 0.12 dB over 1 km would be expected. Hence the effect at low frequencies is negligible and can be ignored for practical purposes in the audio frequency range.

The second atmospheric effect is known as the "molecular relaxation" and is due to the effect of energy dissipated during rotational and vibration behaviour of the oxygen molecules and is strongly dependent on humidity, temperature and pressure.

Most convenient expression is that given by CREMER (Ref 1) and the "molecular relaxation" attenuation expected at 20°C and for relative humidity greater than 20% is

$$\alpha_m = 7.4 \frac{f^2}{\emptyset} 10^{-8} \text{ dB/m} \qquad (2)$$

where α_m = "molecular relaxation" attenuation

f = frequency in Hz

and $\emptyset$ = relative humidity, %

Thus, at a frequency of 1000 Hz and relative humidity of 50% an attenuation of 1.48 dB over 1 km would be expected. At high frequencies this can be very important and the tendency is for attenuation to be greater in dryer air.

For other temperatures within $\pm 10^{\circ}$ of 20°C the "molecular relaxation" attenuation may be approximated reasonably from:

$$\alpha_m = \frac{7.4 f^2 \times 10^{-8}}{\emptyset(1+4\times10^{-6} \Delta t f)} \quad \text{dB/m} \qquad (3)$$

where Δt is the temperature difference from 20°C.

Recent theoretical work by PIERCY (Ref 2) and EVANS, BASS and SUTHERLAND (Ref 3) has shown that, whilst oxygen/water - vapour interaction is indeed the major factor for accounting for the observed molecular attenuation, a secondary relaxation effect involving an interaction between nitrogen and water-vapour is not insignificant and may even dominate the absorption at low frequencies and high humidities.

The latest and the most accurate method of predicting atmospheric absorption is that suggested by SUTHERLAND, PIERCY, BASS and EVANS (Ref 4) and it includes the effect of vibration of nitrogen molecules as well. This method has a firm theoretical base and employs simple algorithms which can be handled easily, for example, by a programmable hand calculator. The predictions of this method have been compared with a large assembly of both laboratory and field data from the literature, see report by SUTHERLAND (Ref 5). This report shows that a comparison of over 850 laboratory measurements with predictions indicates that near 20°C the predicted values agree within about 5%, with the average of the measurements throughout the audio frequency range and over a wide range of humidity.

Figure 3 shows the absorption predicted by the above method, in the practical units of dB/100m for a pressure of 1 atmosphere, a temperature of 20°C, and relative humidity of 70%. Note that at 1kHz the attenuation rate is of order 5 dB/km but that by 10 kHz is over 100 dB/km, thus setting a severe limitation on the distance

over which high frequency sound can be transmitted through the atmosphere. Note also that the attenuation by absorption is constant for a given difference in propagation path lengths unlike geometrical spreading, where it is constant for a given ratio of propagation path lengths. Thus with increasing distance between the source and the receiver, atmospheric absorption tends to become more important, particularly for source with appreciable high frequency content, for example, sources such as aircraft landing and take-off noise and impact pile driving noise.

2.3 EFFECTS OF REFRACTION DUE TO MEAN WIND AND TEMPERATURE GRADIENTS

Over open level ground, there exists, almost always, appreciable vertical wind and temperature gradients; the former because of friction between the moving air and ground, the latter because of heat exchange between the ground and the atmosphere. Because of these gradients, the speed of sound varies with height above the ground. Since the speed of sound waves is relative to that of the medium through which they travel, their velocity relative to the ground is the vector sum of sound velocity and the wind velocity. The wind velocity generally increases with height and the sound waves are refracted towards the ground, giving an increase in the expected level of sound at some distant point (see Figure 4). Upwind the combined velocity decreases with height and the sound waves are refracted away from the earth, producing areas where no sound is heard, i.e. formation of shadow zone. In actual fact, sound can enter a shadow zone as a result of diffraction, scattering off objects, wind turbulence, and by the propagation along the surface of the ground itself.

By day the earth receives solar radiation through the atmosphere and by night gives out radiation, depending on the season of the year. The air layers are subject to diurnal and annual changes and thus the atmosphere is never still. The result of these heat exchanges is that during the day the temperature of the air usually decreases with height; more commonly referred to as negative temperature gradient or lapse conditions. But during the night the temperature of the air may increase with height up to a certain altitude; this is referred to as a temperature inversion or positive temperature gradient. With a negative temperature gradient, the usual conditions on a calm clear afternoon, sound waves are refracted away from the earth forming, in still air, an encircling shadow zone (see Figure 5). With a positive temperature gradient, the condition at night, refraction takes place towards the earth and sound may be augmented in places, rather than attenuated.

The consequences of such temperature inversions are often dramatic. In particular, during the winter period and at night, when such inversions often occur, explosions and loud sounds can be heard over very great distances. This effect indeed causes marked changes in the sound pattern heard during the day and night from airports, trains, highways, and so on. Temperature inversion condition may result in multiple reflections and these are very effective in transmitting sound, especially if the surface is a frozen lake. Occasionally, with an inversion over a lake and on a quiet day, it is possible to understand speech at distances up to perhaps a half mile or more.

Sometimes due to the particular meteorological conditions, the combined effects of wind and temperature near the ground can result in sound velocity gradient as a function of the attitude changing from steeply negative to positive (see Figure 6), so resulting in anomalous sound propagation. Ray-tracing techniques used in conjunction with real atmospheric profiles have a very important application in evaluating the atmospheric focussing of noise from intense sources such as rocket launching sites (see TEDRICK, Ref 6), and in evaluating long-distance propagation of noise from airports, (see INGERSLEV and SVANE, Ref 7). Similar considerations can also account for a number of reported cases where refraction due to particular meteorological conditions has resulted in anomalous sound propagation from explosions being heard hundreds of miles from source (see review by WOOD Ref 8), and even in breakage of windows up to 80 miles away (Ref 9). Also in certain temperature inversion conditions, focussing of sound waves may take place, with an intervening area in a sound shadow (Refs 7 and 10).

The formation of shadow zones can be correctly explained by the use of ray-tracing techniques, but this has less utility when attempting to evaluate the attenuation experienced actually within the shadow zone. Theoretical consideration of this topic has been given by PRIDMORE-BROWN and INGARD (Ref 11), but it is known that under practical conditions the attenuation within the shadow zone must ultimately be limited by turbulent scattering from the illuminated region. In 1959, WIENER and KEAST (Ref 12) carried out an extensive field study of near-ground sound propagation which included sound shadowing, but to date their data on shadow-zone attenuation do not seem to have been compared with theoretical prediction and so the validity of the theory is not fully established. In practice it is found that sound shadows typically lead to excess attenuations of 20 to 30 dB and that such shadows can begin to show themselves within 50m of a source on ground level. Generally the shadow zone will be detected closer to the source at low microphone heights.

KURZE and BERANEK (Ref 13) present two empirical design charts which allow some account to be taken of the effect of wind gradients. The first relates the product of frequency and distance to the degree of attenuation expected downwind at distance up to 1 mile. It indicates that no attenuation is expected below a product of 1.2×10^5 m/sec and rising to 10 dB at 1.2×10^6 m/sec. The implication is that no attenuation is to be expected downward of a source at distances less than 100m and at frequencies below 1200 Hz. The second chart relates the attenuation upwind as a function of the distance to the shadow zone (X_o). Attenuation os 20 dB is expected at distances of twice X_o rising to 25-30 dB at distances above $4 \times X_o$.

Overall, this would seem to be one of the areas of sound propagation which are urgently in need of further attention, since refraction can constitute a major attenuation process under practical conditions of noise propagation.

2.4 EFFECT OF TURBULENCE

Unstable turbulent atmosphere, which is more likely during daytime than at nighttime, will cause fluctuations of the received sound. The magnitude of this fluctuation will generally increase with increasing frequency and with increasing distance (Ref. 14). In 1953, INGARD (Ref. 15) concluded in a review of meteorological effects on sound propagation that over distances of a few kilometers attenuation due to atmospheric turbulence could be a dominant factor, but in arriving at this conclusion Ingard relied heavily on SIEG's (Ref. 16) results. Sieg had carried out observations of mean sound level as a function of distance from a source but his attribution of excess attenuation observed wholly to turbulent scattering is rather dubious according to DELANY (Ref. 17). Actual measurements of scatter by atmospheric turbulence carried out by INGARD and WIENER (Ref. 18) showed only slight dependence on mean wind speed and frequency and more reliable quantitative data were given by INGARD and MALING (Ref 19) which indicated that attenuation due to turbulence is in fact rather small.

A detailed account of the current theoretical position on turbulent scattering in the atmosphere is provided by TATARSKI (Ref. 20) and the reviews by BROWN (Ref. 21) and BROWN and CLIFFORD (Ref. 22).

A very good review of this topic is included in the paper by DELANY (Ref. 17).

For practical purposes, perhaps it is reasonable to assume that

excess attenuation by turbulence is of minor importance and can be ignored (Ref. 13).

2.5 EFFECT OF GROUND ABSORPTION AND REFLECTION

When the source and/or receiver are near the ground and the angle of elevation of the source-receiver line is very small (less than 15^{o}) a frequency selective attenuation considerably in excess of that predicted by geometrical spreading and air absorption is observed. This is due mainly to the absorption of sound by the ground and the interference between the direct and the reflected wave (see Figure 7). The study of this phenomena is closely involved with that of the reflection and interference mechanisms which occur when sound propagates between the source and the receiver close to a relatively plane outdoor surface such as grassland or ploughed fields. Under near-grazing sound propagation conditions, the ground surface plays an important role in determining the level and spectrum of transmitted sound, giving rise to the so-called ground effect, a large dip in the propagation spectrum, normally at below 1000 Hz (see Figure 8). A study by DELANY and BAZELY (Ref 23) and EMBLETON, PIERCY and OLSON (Ref 24) demonstrates how the sound wave propagating from source to receiver will be subjected to interference due to the path length delay and phase change suffered by the sound reflected at a finite impedance ground surface. The proportion of the sound energy reflected at the ground/air interface will be a function of the frequency and angle of incidence for a given ground surface. Generally, normal incidence on perfectly reflecting hard ground will result in a reflection coefficient (R_p) of 1 while absorptive ground will, at low angles of incidence, exhibit an R_p of −1. This value signifies a phase change of 180^{o} on reflection and almost total cancellation of incident and reflected waves at grazing incidence, even though their path lengths are equal (Ref. 24).

The most recent and complete statement of the factors relating to propagation of sound over ground of finite impedance has been made by EMPLETON et al (ref 24). The authors present the summary of the results to date, theory and measured data relating to propagation over grassland surfaces. It is pointed out by the authors that the amplitude reflection coefficient R_p for a plane wave of sound incident obliquely on a plane locally reacting surface may be represented by

$$R_p = \frac{\sin \psi - Z_1/Z_2}{\sin \psi + Z_1/Z_2} \tag{4}$$

where Z_1 = ρc is characteristic impedance of the air

Z_2 = the acoustic impedance of the surface (i.e. the ratio of pressure to the normal component of velocity at a point on the surface)

and ψ = grazing angle

Equation (4) indicates that if ψ is sufficiently small to make the term sin ψ small as compared to the fixed parameter Z_1/Z_2, and thus make R_p effectively -1.

However, KEAST (Ref 25) gives an empirical formula for estimating the frequency at which maximum attenuation will occur over soft ground; derived from the measured data given by PARKIN and SCHOLES (Ref 26). It can be written more conveniently as:

$$f_{max} = \frac{1500}{h \log_{10} (r/0.3)} \qquad (5)$$

where f_{max} = the frequency of maximum effect;

h = the mean height of the source-to-receiver path (in metres)

and r = the distance from source to receiver (in metres).

The attenuation in the octave band containing f_{max} is then calculated from

$$Ag = 15 \log_{10} (0.065\ r/h)\ \text{dB} \qquad (6)$$

if $0.065\ r/h < 1$, Ag is taken as zero. In the two octave bands adjacent to that of maximum attenuation, the attenuation is half the maximum value; in all others it is zero. The maximum value of Ag is assumed to be 15 dB.

One must bear in mind that in reality ground is rarely isotropic or homogenous so the direct application of any theoretical results has to be made with caution; but nevertheless they do explain the essential features observed under field conditions.

2.6 EFFECT OF VEGETATION ON THE GROUND

The presence of taller vegetation such as thick grass, shrubberies or trees has the effect of increasing the excess attenuation due to ground effect, where propagation tends to occur through the medium rather than being reflected from it. Often, particularly in the United States, the use of natural screens is advocated as

a means of confining the noise from ground transportation systems. In fact, the influence of trees is only significant where planting and foliage are dense and even then there are large differences between reported results (Ref 13). In 1946, EYRING (Ref 27) studied propagation through Panamanian jungle, WIENER and KEAST (Ref 28) propagation through dense evergreen forests, EMBLETON (Ref 29) propagation through homogenous deciduous and evergreen woods, whilst AYLER (Ref 30) has reported data relating to dense hemlock and red-pine plantations and to hardwood brush. KURZE and BERANEK (Ref 13) reviewed all the reported data and presented an empirical equation which estimates the attenuation of sound propagating through shrubbery or over thick grass as:

$$\alpha_{\text{shrubbery or grass}} = \frac{0.18 \log f - 0.31}{3.28} \quad \text{dB/m} \qquad (7)$$

where f is the band centre frequency.

Equation (7) implies that 7.0 dB attenuation at 1 kHz and 5.4 dB at 500 Hz over 100m.

EYRING's data was also mentioned by PARKIN and SCHOLES (Ref 26) who suggest that the above excess attenuation rate will be reduced by a factor of 3 when propagation is over soft ground. They also note that sound below 300 Hz is largely insensitive to the type of terrain over which it propagates.

An average value of the attenuation of sound propagating through all types of forests is given by the expression (Ref 13):

$$\alpha_{\text{forest}} = 0.01\, f^{1/3} \text{ dB/m} \qquad (8)$$

This implies that only 10.0 dB attenuation at 1000 Hz is expected over 100m, so that a rather thick belt of trees would be required to achieve effective noise screening.

For bare deciduous trees (Ref 31) values should be reduced to

$$(0.01\, f^{1/3} - 0.10) \quad \text{dB/m} \qquad (9)$$

Finally, one must bear in mind that the majority of work on sound propagation was performed outside Europe. The typical tree growth of indigenous varieties in Europe is relatively sparse on a trunk with few branches reaching ground level, and these are different from trees grown in North and South America. In Europe the undergrowth too is on a different scale from that in the United States, with relatively slight cover, even in our forest areas. Irrespective of these large differences, the data used in Britain

is that of researchers in America who measured transmission through various types of jungles. Therefore, perhaps Equation (8) is likely to over-estimate the attenuation values in some cases. In the case of trees with bare trunks and minor undergrowth, the use of Equation (9), is likely to give better estimates. Further, it must be noted that hedges and bushes provide almost negligible attenuation unless extremely dense, with branches reaching the ground. Even then their application is limited, for unless the hedge is extremely tall the sound is propagated over, rather than through it.

2.7 EFFECT OF RAIN, FOG OR SNOW IN THE AIR

The propagation of sound through fog or light precipitation can produce scattering and attenuation of sound waves. One of the most reliable field measurements were carried out by WIENER in 1961 (Ref 32) under sea-frog conditions where the range of visibility was about 300m. These results indicated an excess attenuation of about 1 dB/km.

Indeed, the effects of precipitation are far more important in changing sound transmission by changing the humidity and the temperature distributions in the lower atmosphere. In practice, inland mists and fog are usually associated with stable meteorological conditions, with low wind speed and with small temperature gradients near the ground. In these sorts of conditions there is unlikely to be any shadow zone formation, except maybe at fairly large distances from source; and even when light rain occurs, as in pre-frontal fog, there is no noticeable additional attenuation at low frequencies.

Therefore, for the purposes of planning it is reasonable to disregard any possible effects of rain, fog or snow in the air, extra to those of normal atmospheric absorption, except to include an excess attenuation of about 1 dB/km to allow for possible scattering effects.

2.8 EFFECT OF BARRIERS

Walls or other artificially made barriers are often employed to reduce the noise levels propagated from highways or any other noisy premises. But inevitably this is only effective if the source or receiver are near the ground and close to the barrier, and if the barrier has sufficient mass, height and length, so that the sound can reach the observer only by diffraction around the edges of the obstacle. Other important factors which should be considered in design of barriers are structural stability,

safety, appearance and ensuring that there are no air paths through or under the barrier.

KURZE (Ref 33) and MAEKAWA (Ref 34) have recently published two comprehensive reviews of the state of knowledge on barriers, encompassing rigid and absorbing barriers, barriers on hard and absorbing ground and barriers of various shapes. KURZE and BFRANEK (Ref 13) and TATGE (Ref 39) have also discussed the topic to a certain degree.

For the case of long, rigid and thin barriers, the barrier attenuation in each frequency band can be calculated by the expression (Ref 36):

$$\text{Barrier attenuation} = 10 \log_{10} (3 \pm 20\ N)\ \text{dB} \qquad (10)$$

where the quantity N is defined as

$$N = \frac{2}{\lambda}(a + b - R) \qquad (11)$$

where λ = acoustic wavelength (in m) based upon the band centre frequency (bandwidth not exceeding an octave);

a = distance from source to the edge of the barrier (in m);

b = distance from receiver to the edge of barrier (in m);

and R = straight line distance from source to receiver (in m).

In Equation (10), normally the positive sign is to be observed within the brackets but the negative sign is to be assumed if there is a direct sight - line from the source to the receiver (i.e. if the receiver is above the shadow zone of the barrier).

The above approximation is used by JUDD and DRYDEN (Ref 36) and is derived from the results given by MAEKAWA (Ref 37).

In practice, it is realistic to say that barriers in field situations may provide a maximum attenuation of up to as much as 30 dB, but in the majority of cases a value of 15-20 dB is more realistic. In field situations the shielding afforded by the barrier is low because of the sound energy scattered into the barrier shadow region by atmospheric turbulence.

It should be noted that the above approximation, Equation (10), applies to barriers the thickness of which is less than λ, the wavelength. Thicker or wide barriers, e.g. buildings, would

always give a greater attenuation than thin barriers. Accurate attenuation values can be obtained by the use of theories given by PEARCE (Ref 38) and MAEKAWA (Ref 34). Perhaps another fairly simple and reasonably accurate method of estimating the barrier attenuation given by the thick barrier is to derive the effective height and position of the equivalent barrier which is defined by the intersection of two straight lines both just grazing the top edges of the wide barrier, one drawn from the receiver and one drawn from the source. Equation (10) is then applied to the equivalent barrier.

Finally, it is a common practice to ignore the additional attenuation due to the ground absorption when calculating the effect of a barrier since the near-ground rays are obstructed. However, under certain conditions (e.g. low barriers erected on grassland) it is possible for these ground absorption effects to exceed the assessed shielding of the barrier.

2.9 COMPARISON OF EXCESS ATTENUATION

It is useful to examine the relative significance of each of the excess attenuation factors affecting outdoor sound propagation. Table 1 shows the values of excess attenuation over 100m for each of the important factors affecting propagation. It is clearly indicated that wind profiles and ground cover have a significant effect on the sound propagation, and also that the atmospheric absorption can be important for sound with high frequency content. It is further shown that interference phenomena can constitute a marked change in the received spectra and also the effect of barriers can be significant for a source at ground level. The effect of precipitation, turbulence and the temperature profiles is considered to be negligible for outdoor sound propagation over small distances.

3.0 PROPAGATION OF SOUND IN URBAN AREAS

Recently the propagation of sound in an urban area has become increasingly important. In particular, the multiple propagation in a street is of interest for both ground-based sources such as road traffic or construction devices, and elevated sources (above the general building height) such as low-flying aircraft or helicopters.

Before going on to discuss this topic, it seems appropriate that urban climate and its effect on sound propagation be stated briefly. In a city, sound from a source travels appreciable distances in the layer above the buildings, and one can consider

the ground plane to be at average roof top level, with the usual refraction effects. Below this the climate is completely different and sound reaches the observer as energy scattered and diffracted into the street. City and urban areas modify the local climate and create their own micro-climate as well. There is likely to be strong turbulent mixing in built-up areas, owing to the presence of many roughness elements and man made heat sources.

The slope of the temperature profiles in the street areas is always found to be small and its sign always negative. This is quite different from open terrain where appreciable temperature gradients, both positive and negative, are often found. In streets, maximum temperature gradients and wind gradients are very small indeed, again quite different from open terrain where frequently they are appreciable and control the sound propagation over the ground. So in these street areas one can expect that excess attenuation due to temperature or wind gradient induced refraction effects to be small, and of no great significance in this situation (Ref 39).

The propagation of sound through streets is likely to suffer multiple reflection effects and diffusion of the sound field. Therefore, the only acoustical propagation effects of interest here are geometric spreading, atmospheric absorption, reflection and surface absorption and scattering.

WIENER, MALME and GOGOS (Ref 39), and DELANY et al (Ref 40) have reported field studies of sound propagation in streets with the source located within the street channel. The data of WIENER et al (Ref 39) shows that the attenuation both upwind and downwind, along city streets, is accounted for primarily by the 6 dB per doubling of distance law and by the usual atmospheric absorption. Apparently, in this situation, there is very little excess attenuation as a result of multiple reflections and scattering from the building faces. In part, this may be due to the fact that WIENER used a highly directive sound source (a horn loud-speaker) pointed along the axis of the street, which may have tended to minimise reflected paths.

DELANY (Ref 40) conducted his measurements in a fairly narrow street in which the houses were very close together without appreciable space between them. The noise source was fairly heavy traffic moving along a main artery at right angles to the street in which the data was taken. These results showed that there are ranges near the source along which the sound attenuates at 7 to 8 dB per doubling of distance. In this case, no allowance was made for atmospheric absorption.

DELANY, COPELAND and PAYNE (Ref 40) have also produced a design chart, based upon empirical data, which gives the shielding of traffic noise associated with a row of houses parallel to a main road (see Figure 9).

More recently, the propagation of railway noise in residential areas has been studied by GILL (ref 41) and WALKER (Ref 42). These results are summarised in Table 2. This table indicates the likely reduction in maximum sound pressure level due to screening by various forms of housing development.

PIERCE and KINNEY (Ref 43) have carried out measurements on aircraft noise intrusion into a city street. In these experiments a helicopter was flown over a street. The comparison of the fly-over of open terrain (airport) with the fly-over of the city street showed that the sound pressure level time history pattern for the city-street noise is much shorter in duration. Similarly, the peak level was slightly higher as a result of multipath propagation.

Review of this rather fragmented topic by LYON (Ref 44) indicates that certain general "rules of thumb" are beginning to emerge, such as an attenuation rate down city streets away from concentrated sources at a rate between 7 and 8 dB per doubling of distance. Associated with this, there is an extra attenuation of 10 to 20 dB when one turns into a cross street.

These "rules of thumb" are certainly in agreement with the data reviewed by DELANY (Ref 45) from many countries, and have suggested a formula which seems more reasonable:

Attenuation = 7 dB per doubling of distance, plus an excess due to screening which depends on the urban character and can vary from about 10 dB for very open residential areas to over 20 dB for densely built-up areas.

A more recent study by DELANY (Ref 46) describes model studies at 1:30 scale of street propagation situations. He find that field data can, in general, only be reproduced when averages over source locations are made and when surface irregularities are introduced both on building and ground surfaces.

Finally, it is perhaps still true to say that we cannot yet calculate with confidence the noise levels from known source distributions in multipath situations.

4.0 PRACTICAL APPROACH TO PROPAGATION OF TRANSPORTATION NOISE

This section briefly discusses the procedures used to overcome some of the primary difficulties in predicting the noise from some common transportation modes. It is quite common to lump together the various factors producing attenuation; and generally in practice, the effects of wind and temperature gradients are ignored for propagation over relatively short distances. In some cases, it is sometimes more practical, perhaps, just to use the empirically measured attenuation rates per doubling of distance over the most common types of ground cover, including of course the effects of any barriers as well.

Moving aircraft can indeed be considered as a series of moving point sources, and when considering the propagation of this noise, air absorption is a predominant factor. However, if the line of sight to the aircraft has an angle of elevation of less than about 15^{0}, ground absorption has an increasing effect. Turbojet and turbofan engined types of aircraft produce a noise spectrum which attenuates by 8 dB per doubling of distance, unless the angle of elevation is less than 15^{0}, in which case the attenuation rate increases to 10 dB per doubling of distance at 0^{0} elevation. Obviously, the control of npise from over-flying aircraft is not practical by the use of barriers; only a high barrier, or perhaps already existing buildings, can sometimes be used to reduce the noise from aircraft operations on the ground. However, the reduction of noise from aircraft on the ground is only small since the source is generally fairly high up compared to traffic or railway noise sources.

On the other hand, traffic noise is generally considered to be an incoherent line source, consisting of numerous point sources along its length. Traffic noise sources are generally on or near the ground and are heavily subjected to ground absorption, although the reflectivity of the ground at source allows propagation in all directions above the ground. The method of prediction of traffic noise levels issued by the DOE (Ref 47) recommends the use of an empirical equation to estimate the effect of ground absorption over soft ground.

The soft ground attenuation formula is:

$$\Delta L_{10} = -10 \log\left(\frac{d_1}{13.5}\right) + 5.2 \log\left(\frac{3h}{d+3.5}\right), \qquad (12)$$

valid for $1 \leqslant h \leqslant (d + 3.5)/3$ and

$$\Delta L_{10} = -10 \log \left(\frac{d_1}{13.5}\right) \tag{13}$$

valid for $h > \frac{(d+3.5)}{3}$

and $$d_1 = \{(d + 3.5)^2 + (h - 0.5)^2\}^{\frac{1}{2}} \tag{14}$$

where d is the horizontal distance from edge of nearside carriageway and h is the measurement height above ground.

This implies that at a given measurement height, the L_{10} level attenuates at a rate of 4.5 dB per doubling of distance. DOE's prediction method (Ref 47) also gives a method of estimating the effect of barriers in terms of the path difference.

Railway noise is generally considered as a moving line source the major part of the noise being generated only a few inches above the ground by rail/wheel interaction. Thus it is likely to be affected considerably by the nature of the ground cover and by shielding by even the smallest barrier near the track. This applies to both electric and diesel-powered units. In some specific cases the diesel unit exhaust noise propagates considerable distances since it is fairly high above the ground and not greatly affected by the atmospheric absorption.

5.0 CONCLUSIONS

From this brief review of the phenomena affecting outdoor sound propagations, it can be seen that climatic and ground covering have a pronounced effect on the attenuation of a sound wave. But to separate each of the many parameters and to give the magnitude of their individual effects is almost impossible from most available experimental results. Although the importance of sound refraction caused by wind and temperature gradient is well established, particularly on the macro-scale, there is certainly a further need to quantify accurately the attenuation associated with shadow zones created by wind and temperature in a real atmosphere, because shadowing can constitute the major component of attenuation for noise propagation from surface and air transportation. Although the physical phenomena associated with ground-interference effects is now broadly understood, there is still a need for further systematic field studies to establish the variability to be expected under practical conditions due to different surface coverings. In general, it appears that scattering losses caused by turbulence, under typical atmospheric conditions, are less than those associated with molecular relaxation processes. In fact, at higher frequencies

air absorption certainly prefominates; and indeed it can be adequately predicted over a wide range of frequency, humidity and temperature to an accuracy acceptable for most practical purposes. On the other hand, the effect of fog and precipitation is considered to be negligible.

However, when several of the above factors act simultaneously, the problem of understanding atmospheric propagation still remains. Of particular interest is the way that scattering from inhomogeneities limits the attenuation associated with refraction, diffraction and ground interference effects. Another problem is the way in which mild temperature inversion or small changes in wind vector can obviate all ground absorption effects and so produce large changes in observed attenuation because of change in meteorological conditions.

In spite of all this, it is general practice to predict the noise at a location with International Standard Atmosphere (I.S.A.) conditions (760 mm of mercury barometric pressure, a temperature of 15°C and 70% relative humidity, wind less than 5 knots, with no temperature lapse rate) representing a supposed set of average conditions. Although these conditions can be approximated by day, they never occur at night, a major time of noise annoyance from aircraft. To the author's knowledge, no one has yet published results of research into sound propagation at night. With the increased accent on noise pollution control, especially during hours of relaxation and rest, this omission is rather conspicuous and should be rectified as soon as possible.

REFERENCES

1. L. CREMER. Raumakustik, Vol. 11, p. 27, S. Hirzel Verlag, 1961.

2. J.E. PIERCY (1969). J. Acoust. Soc. Am., 46, 602. Role of vibrational relaxation of nitrogen in the absorption of sound in air.

3. L.B. EVANS, H.E. BASS and L.C. SUTHERLAND (1972). J. Acoust. Soc. Am., 51, 1565. Atmospheric absorption of sound: theoretical predictions.

4. L.C. SUTHERLAND, J.E. PIERCY, H.E. BASS and L.B. EVANS (1974). J. Acoust. Soc. Am., 56, SI(A). Method for calculating the absorption of sound by the atmosphere.

5. L.C. SUTHERLAND. Review of experimental data in support of a proposed new method for computing atmospheric absorption losses. Department of Transportation of United States Report No. DOT TST 75 87.

6. R.N. TEDRICK (1963). Sound, 2(6), 24. Meteorological focussing of acoustic energy.

7. FL INGERSLEV and C. SVANE (1968). Preliminary studies of sound propagation in the lower layers of the atmosphere. Proc. 6th ICA, Japan, Paper F-3-6.

8. A. WOOD. Acoustics. Blackie, London, 1940.

9. J.W. REED. Atmospheric signals from explosions and their interpretation. Sandia Corporation Report, SCR-163.

10. P. ROTHWELL (1955). J. Acoust. Soc. Am., 28(4), 656-665. Sound propagation in the lower atmosphere.

11. D.C. PRIDMORE-BROWN and U. INGARD (1955). J. Acoust. Soc. Am., 27, 36. Sound propagation into the shadow zone in a temperature - stratified atmosphere above a plane boundary.

12. F.M. WIENER and D.N. KEAST (1959). J. Acoust. Soc. Am., 31, 724. Experimental study of the propagation of sound over the ground.

13. U. KURZE and L.L. BERANEK. Sound propagation outdoors. Noise and Vibration Control, L.L. Beranek Ed., McGraw-Hill, 1970.

14. V.I. TATARSKI. Wave propagation in turbulent medium. Dove 1967.

15. U. INBARD (1953). J. Acoustical Soc. Am., 25(3), p. 405-411. A review of the influence of meteorological conditions on sound propation.

16. H. SIEG (1940). Elekt. Nach. Technik., 17, 193. Uber die Schallausbreitung im Freien und ihre Abhangigkeit von den Wetterbedingungen.

17. M.E. DELANY (1977). Acustica, 38, 201-223. Sound propagation in the atmosphere: A historical review.

18. U. INGARD and F.M. WIENER (1958). J. Acoustical Soc. Am., 30, 670. On the scattering of sound by atmospheric turbulence.

19. U. INGARD and G.C. MALING (1963). J. Acoust. Soc. Am., 35, 1056. On the effect of atmospheric turbulence on sound propagated over ground.

20. V.I. TATARSKI. The effects of the turbulent atmosphere on wave propagation. NAUKA, Moscow, 1967 (In Russian). (English translation with amendments published by the Israel Program for Scientific Translation, Jerusalem, 1971).

21. E.H. BROWN (1974). J. Geophys. Res., 79, 5567. Some recent NOAA theoretical work on echo sounding in the atmosphere.

22. E.H. BROWN and S.F. CLIFFORD (1976). J. Acoust. Soc. Am., 60, 788. On the attenuation of sound by turbulence.

23. M.E. DELANY and E.N. BAZLEY (1971). J. Sound and Vibration 16(3). A note on the effect of ground absorption in the measurement of aircraft noise.

24. T.F.W. EMBLETON, P.E. PIERCY and N. OLSON (1976). J. Acoust. Soc. Am., 59(2) 267-277. Outdoor sound propagation over ground of finite impedance.

25. D.N. KEAST (1975). Predicting noise environments around proposed industrial sites. Paper presented to 89th Meeting ASA.

26. P.H. PARKIN and W.E. SCHOLES (1965). J. Sound Vibration, 2(4). 353-374. The horizontal propagation of sound from a jet engine close to ground, at Hatfield.

27. C.F. EYRING (1946). J. Acoust. Soc. Am., 18, 257. Jungle acoustics.

28. F.M. WIENER and D.N. Keast (1959). J. Acoust. Soc. Am., 31, 724. An experimental study of the propagation of sound over the ground.

29. T.F.W. EMBLETON (1963). J. Acoust. Soc. Am., 35, 1119. Sound propagation in homogeneous deciduous evergreen woods.

30. D. AYLOR (1972). J. Acoust. Soc. Am., 51, 197. Noise reduction by vegetation and ground.

31. A Guide to measurement and prediction of the equivalent continuous sound level L_{eq}. The Noise Advisory Council report by a Working Party for the Technical Sub-Committee of the Council, 1978.

32. F.M. WIENER (1961). J. Acoust. Soc. Am., 33, 1200. Sound propagation over ocean waters in fog.

33. U.J. KURZE (1974). J. Acoust. Soc. Am., 55(3), 504-518. Noise reduction by barriers.

34. Z. MAEKAWA (1974). Environmental sound propagation. Proceedings of the 8th International Congress on Acoustics, London, Invited Papers, 29-46.

35. R.D. TATGATE (1973). J. Acoust. Soc. Am. 53(5), 1317-1319. Barrier wall attenuation with a finite-sized source.

36. S.H. JUDD and S.L. DRYDEN (1975). J. Acoust. Soc. Am., 58, Suppl. No. 1, p.S.16 (Abstract). Application of a computer model for predicting remote noise levels.

37. Z. MAEKAWA (1968). Applied Acoustics, 1, 157-173. Noise reduction by screens.

38. A.D. Pearce (1974). J. Acoust. Soc. Am. 55(5), 941-955. Diffraction of sound around corners and over wide barriers.

39. F.M. WIENER, C.I. MALME and C.M. GOGOS (1965). J. Acoust. Soc. Am., 37, 738-747. Sound propagation in urban areas.

40. M.E. DELANY, W.E. COPELAND and R.C. PAYNE (1971). Propagation of traffic noise in typical urban situations. National Physical Laboratory Report Ac. 54.

41. H.S. GILL (1975). The propagation of railway noise in residential areas. ISVR Technical Report No. 73, University of Southampton.

42. J.G. WALKER (1977). J. Sound Vibration, 51(3), 393-398. Factors affecting railway noise in residential areas.

43. W.A. KINNEY and A.D. PEARCE (1973). Helicopter noise experiments in an urban environment. Interim Report, Department of Transportation (United States), Contract DOT-TSC-93, MIT.

44. R.H. LYON (1974). J. Acoust. Soc. Am., 55(3) 493-503. Role of multiple reflections and reverberation in urban noise propagation.

45. M.E. DELANY (1969). Range prediction for siren sources. NPL Aero Special Report 33, National Physical Laboratory, Teddington, Middlesex.

46. M.E. DELANY, A.J. RENNIE and K.M. COLLINS (1972). Scale model investigations of traffic noise propagation. National Physical Laboratory Report Ac 58.

47. Calculation of road traffic noise. Department of the Environment and Welsh Office Joint Publication. London, HMSO, 1975.

TABLE 1: EXCESS ATTENUATIONS OVER A DISTANCE OF 100m

Type of Attenuation	Attenuation in dB over 100m 500 Hz	1kHz
Atmospheric Absorption		
(i) Viscosity/Conduction	3×10^{-3}	0.01 (20^{o}C, 50% R.H.)
(ii) Relaxation	0.04	0.15
Wind Profiles	Slight augmentation downwind, up to 30 dB attenuation upwind.	
Temperature Profile	Little effect likely at short distances	
Turbulence	Small effect	
Ground Cover		
(i) Short Grass	3.0	3.0
(ii) Thick Grass	5.4	7.4
(iii) Trees	8.0	10.0
Interference	Maximum of 15 dB in octave band indicated and 7.5 dB in adjacent bands.	
Rain, Fog or Snow	0.1	0.1
Barriers		
(i) Source at ground level	Maximum of 15-20 dB; depending upon the source - barrier-receiver geometric configuration	
(iii) Source in the air	Negligible	

TABLE 2: SCREENING EFFECTS OF HOUSES ON PROPAGATION OF RAILWAY NOISE

Type	Detached/ semi-detached	Terrace 150 m long	Terrace 300m long	
No. of rows	1	$\geqslant 2$	1	$\geqslant 2$
Excess attenuation dB(A)	8	12	15	17

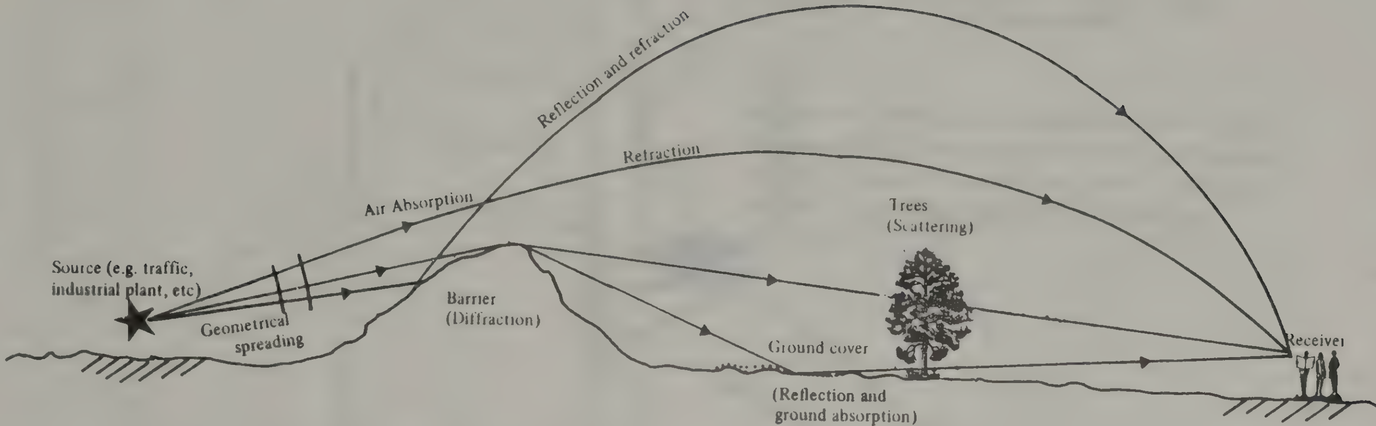


Figure 1. Physical attenuation phenomenon associated with a source near the ground

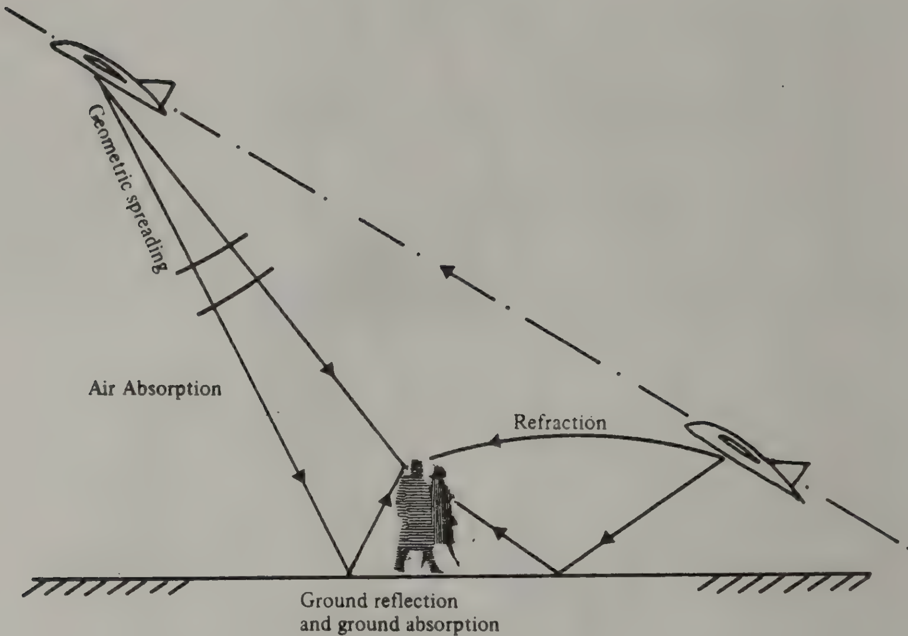


Figure 2. Sources of attenuation for airborne aircraft noise

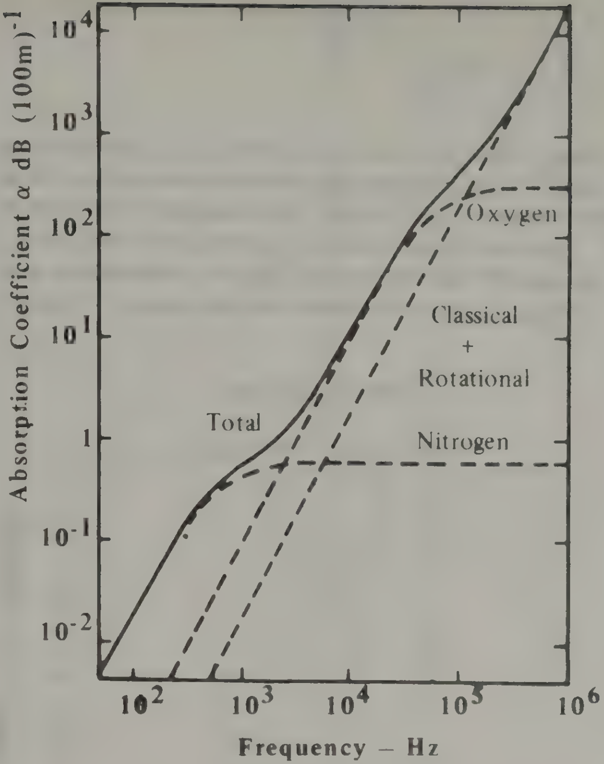


Figure 3 **Predicted atmospheric absorption in dB/100m for a pressure of 1 atm, temperature of 20^{0} C and relative humidity of 70%.**

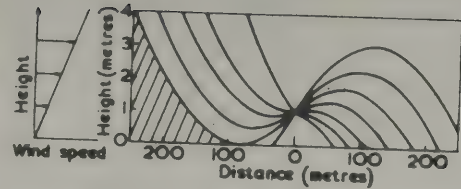


Figure 4 Effect of wind gradient on sound propagation. The sound waves are refracted by the vertical wind shear, and a "shadow region" can exist where little sound is detected.

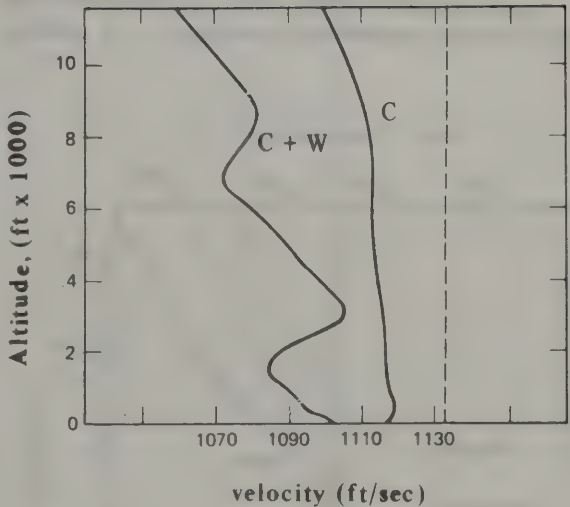


Figure 6 Showing the combined effect of wind and temperature on the sound velocity profile as a function of attitude. C is the velocity due to temperature differentials, and (C+W) indicates the sum of both temperature and wind effects. (From P. Rothwell; J. Acoust. Soc. Am., 28, 656 (1956)).

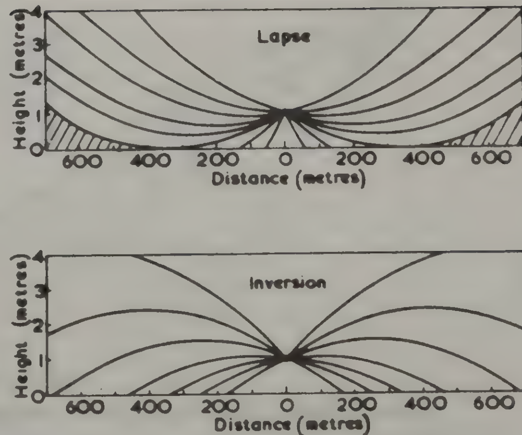


Figure 5 Effect of temperature gradient on sound propagation.

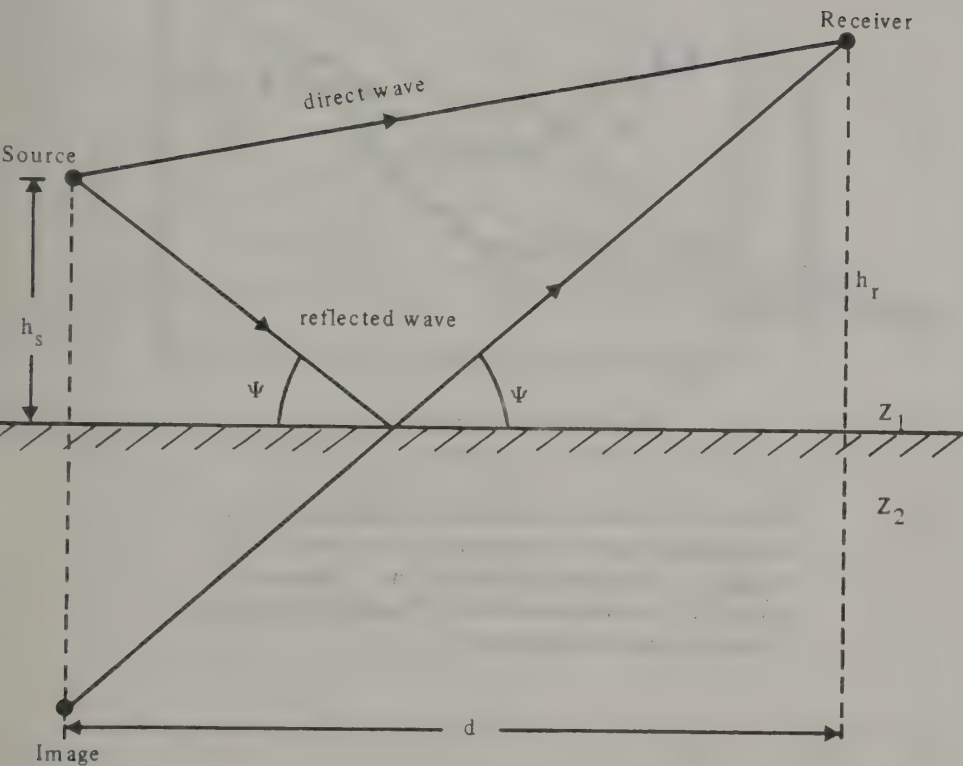


Figure 7 Reflection of sound from flat ground with impedance Z_2

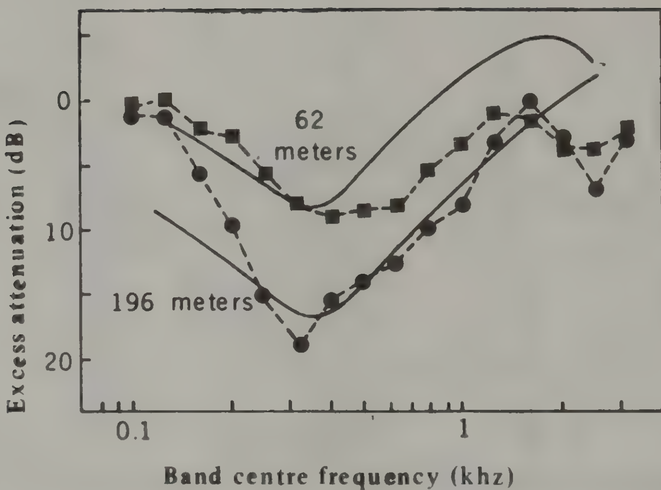


Figure 8 Excess attenuation caused by ground absorption; receiver height, 1.83 meters; source height, 1.52 meters. Symbols ■ theoretical data; ● experimental data. Parameter on curves is source-receiver distance.

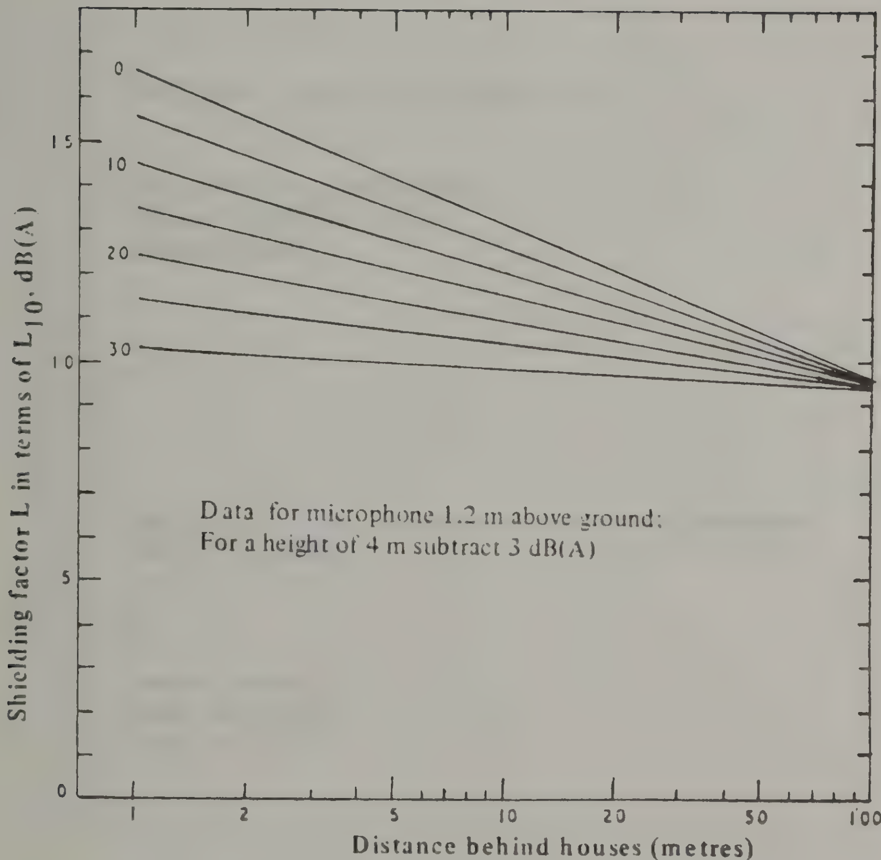


Figure 9 Shielding of traffic noise associated with a row of houses parallel to a main road; parameter is percentage open area at house facades

NATIONAL SOCIETY FOR CLEAN AIR

46th ANNUAL CONFERENCE
15–18 OCTOBER 1979
SCARBOROUGH

THE EFFECTS OF WEATHER ON NOISE MEASUREMENT AND ASSESSMENT

by

Peter Sutton,
Esso Refinery,
Fawley

National Society for Clean Air
136 North Street
Brighton BN1 1RG
England

1. INTRODUCTION

The propagation of noise in the open, and therefore the level of the noise at a distant location, is influenced by atmospheric conditions - that is to say, by the weather.

Strictly speaking, we should refer to <u>sound</u> propagation. Sound consists of pressure waves in the atmosphere which are received and sensed by the ear and its auditory system. Noise is unwanted sound. This sound is what we hear and noise is what we hear but would rather not. For the purposes of this paper it is assumed that all sound from industrial works which reaches the neighbourhood is unwanted and so can be referred to in general as noise.

In assessing noise in the neighbourhood of a works we are concerned with intrusiveness - with the risk of causing annoyance. Annoyance depends on noise level and character. Measurement of noise in A-weighted decibels (dBA) takes care of general character (frequency content). Noticeable features present in the noise, such as whines and whistles, increase the annoyance value. Account should always be taken of these in assessing noise with respect to annoyance. Generally speaking, the first step in neighbourhood noise control is to suppress prominent characteristics and for the purposes of this paper it is assumed that this has been done. So we are concerned here with assessment of noise in terms of its measured level in dBA.

2. NOISE PROPAGATION IN THE OPEN

The simplest pattern of noise radiation is that from a single small source located on an expanse of flat hard ground in still air with uniform temperature and humidity. The noise then radiates out in a hemispherical pattern and the measured noise level decreases initially by 6dB with doubling of distance from the source.

Over large distances the rate of decrease would be something more than 6dB per doubling of distance because of energy loss in the air, but the pattern would still be uniform.

In practice the situation is never as simple as this. For one thing, the ground is seldom flat and hard over the whole distance from the works to the neighbourhood housing. However, the topography is specific to a particular location and it does not change from day to day so topographical effects do not concern us here. Atmospheric conditions, on the other hand, do vary from day to day.

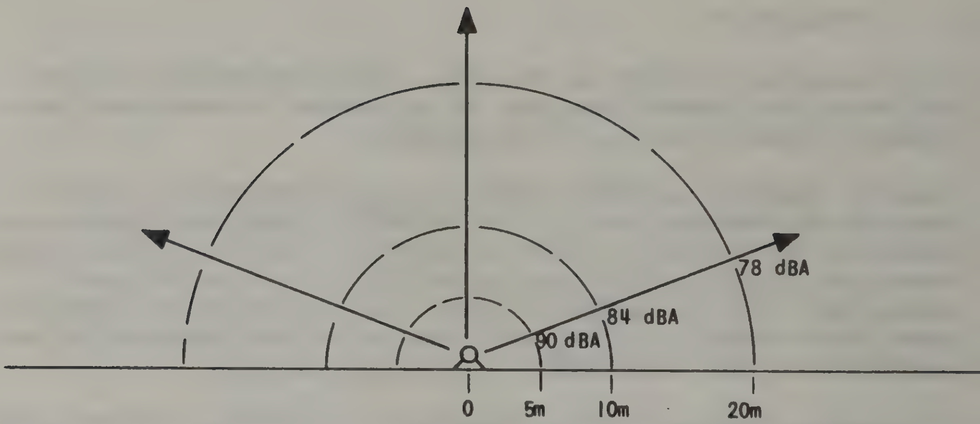


Fig. 1 Hemispherical radiation of noise over flat hard ground

The atmospheric factors which affect noise propagation significantly are:

- humidity
- temperature
- variation of temperature with height above ground (temperature lapse rate)
- wind speed and direction
- variation of wind with height above ground (wind velocity gradient)

These conditions vary from hour to hour and day to day. This means that even when a works emits a constant noise the noise level heard or measured at a distance from the works varies from hour to hour and day to day as weather conditions vary.

Before going on to discuss the effects of weather on the noise levels experienced in the neighbourhood of an industrial works, we should consider some general aspects of neighbourhood noise measurement.

3. MEASUREMENT OF NOISE LEVEL

The conventional sound level meter measures the total noise level.

It is completely non-specific. If sounds from two or more sources are present at the same time, the sound level meter itself cannot distinguish between them.

This paper is concerned with measurement and assessment of noise from a particular works some distance away, and there is bound to be some noise from other sources present at the measuring location. The following terms are convenient for differentiation:-

Ambient noise level. The total noise level at a location. This is the level measured by the sound level meter.

Works noise level. The level of the noise coming specifically from the works in question.

Background noise level. The level of noise from all sources other than the works in question. This noise may come from other works, traffic, people and so on.

The ambient noise level is, of course, the sum of the works noise and background noise.

The British Standard procedure for assessing neighbourhood noise from industrial activities, BS 4142 (1), assumes that it is possible to measure works noise level. This is so only when:-

(i) The works noise can be turned off. That is to say the ambient level can be measured with and without the works noise present, so background noise can be measured separately.

(ii) The works noise is much louder than the background, so the measured ambient level is, essentially, the works noise level.

The conventional sound level meter cannot identify whether this is the case. Special equipment, such as directional microphones, can be used but interpretation of the measurements is difficult and standard procedures have not been developed. In practice one has to rely on the ear to tell whether the ambient noise is dominated by works noise.

Fig.2 shows graphical records of the noise level measured at the edge of a residential area adjacent to the boundary fence of a large works. The nearest plant is about 300m back from the fence. The local main road runs between the works and the housing, so

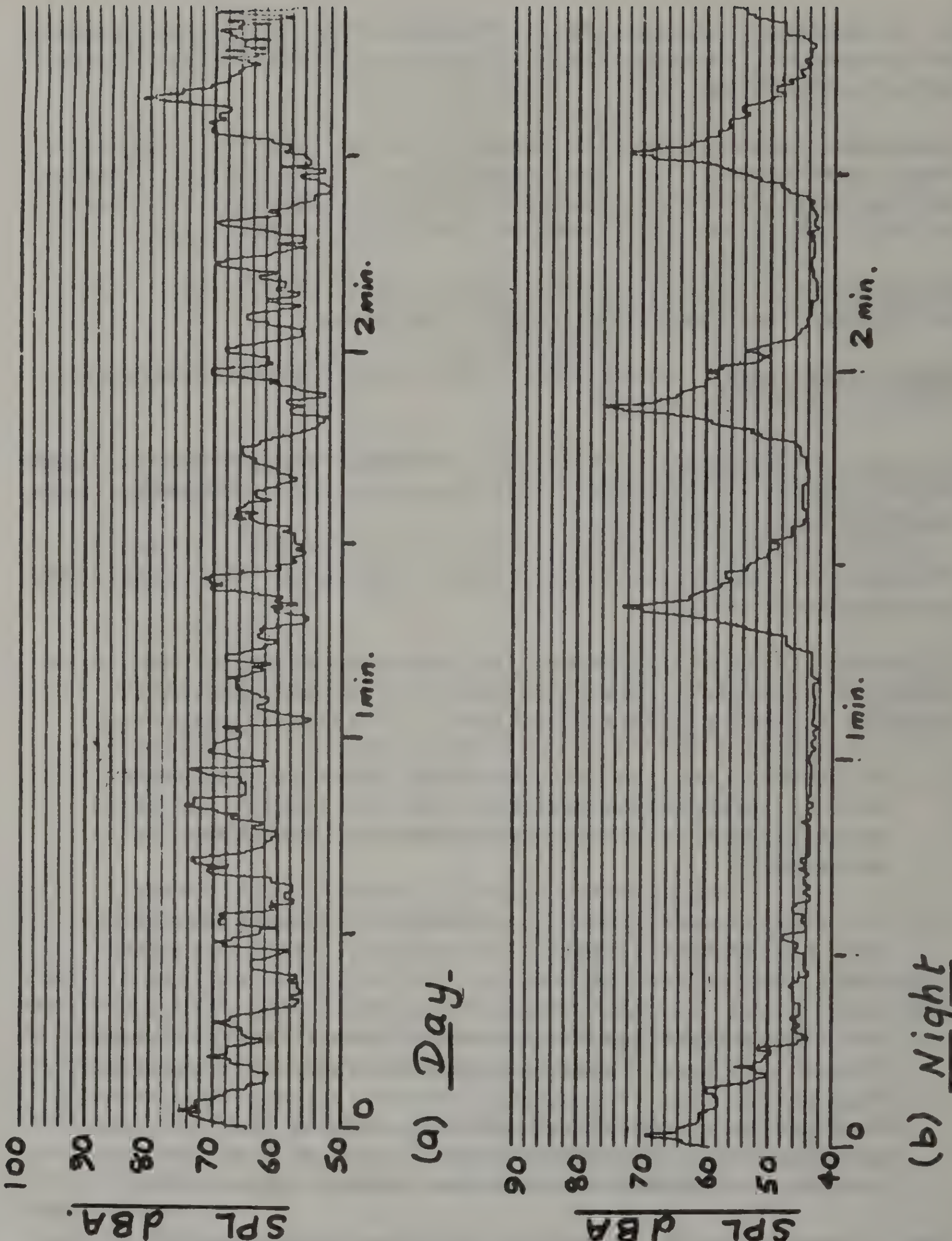


Fig. 2 Continuous noise records taken in front of housing opposite the boundary fence of a large works. There is a busy local road between the works and the housing.

the measured noise level is made up of contributions from the works, from road traffic, occasional aircraft, other noises in the residential area and other neighbouring works.

The noise generated by the works was constant, so the works noise level alone would show as a nearly constant value on the chart. The daytime record (2a) shows no evidence of a base-line level and the ear was able to detect works noise with difficulty and only occasionally against the traffic noise.

The night-time record (2b) taken at midnight shows a nearly constant noise level beneath the traffic noise. This emerges for short periods between the noise peaks from passing vehicles. The evidence of the graphical record suggests that this is the level of noise from the works and that it is 42-44 dBA. The graphical record alone is not conclusive; this base noise level could come from other nearby works or the more distant large town. The evidence of the ears at the time is required to determine whether this is, in fact, the true works noise level. In this case, the ears indicated that it was.

Fig. 3 shows a record taken at night about 1km away. This shows a base level of 38-40 dBA and it would be tempting to interpret this as the works noise level. However, the evidence of the ears was that noise from distant traffic and other sources made a significant contribution. The works in question was audible but not dominant. The only conclusion which can be drawn is that the works noise level was something less than 38 dBA; one cannot be more precise than that.

4. WEATHER EFFECTS

Meteorological conditions have a considerable effect on noise propagation. The level of noise from a works measured at a distant point varies from day to day even if the noise generated in the works is constant.

Fig. 4 shows works noise level measured on a number of different days at locations 700m to 2km (1/2 to 1.1/2 miles) from a large works (2). The distance scale is logarithmic because this normally gives a nearly straight line graph of decreasing noise level with increasing distance.

Fig. 4 indicates the wide day to day spread in measured works noise levels, the degree of variation increasing with distance. It also shows that the decrease in noise level between 1km and 2km distance varies from 10 dBA to 20 dBA (as compared with 6dBA accounted for by geometric spreading alone).

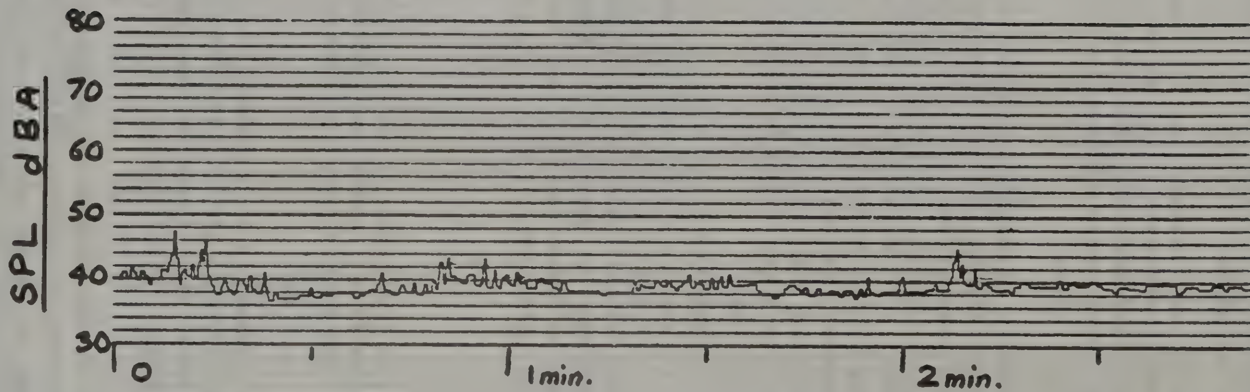


Fig. 3 Continuous noise record taken at night on the edge of a quiet residential area about 1 km from the boundary of the works in Fig. 2. Base ambient noise level was judged by ear to be made up of noise from the works in question, from other works and from distant roads. Peaks were caused by cars on a road at least 200m distant. Fluctuations in the base ambient level were judged to be caused partly by fluctuations in distant traffic flow and partly by minor wind variations.

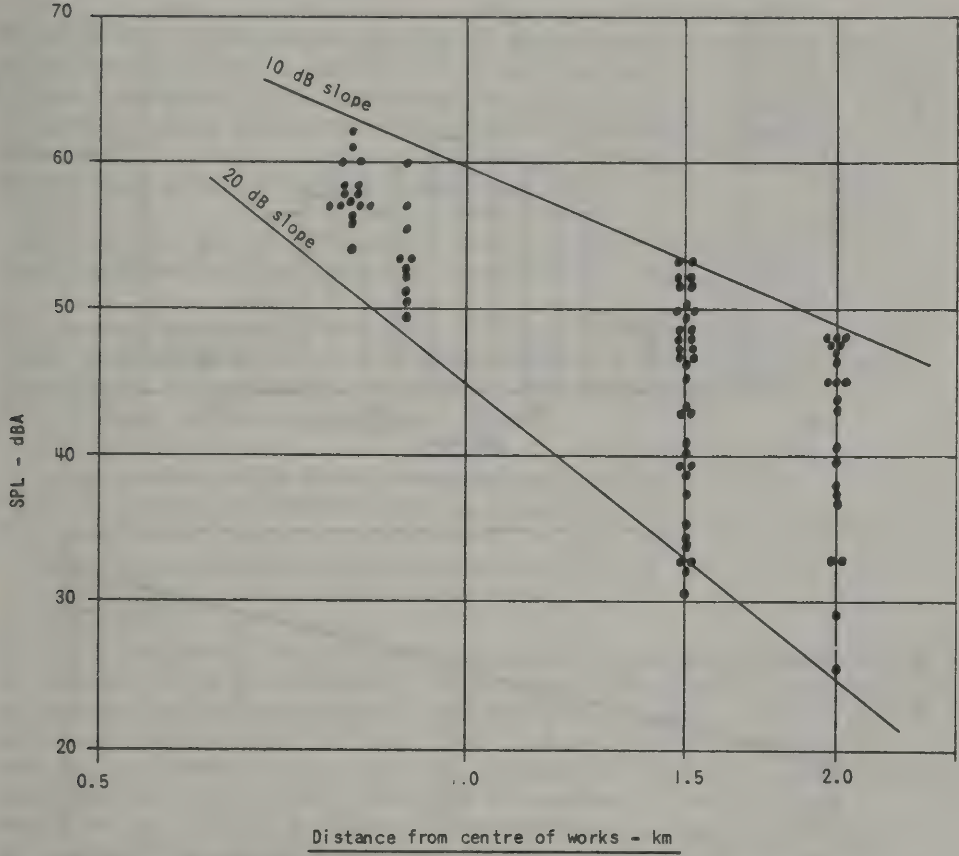


Fig. 4 Spot measurements of works noise level taken over a long period showing wide day to day spread and reduction of level with increasing distance. (2)

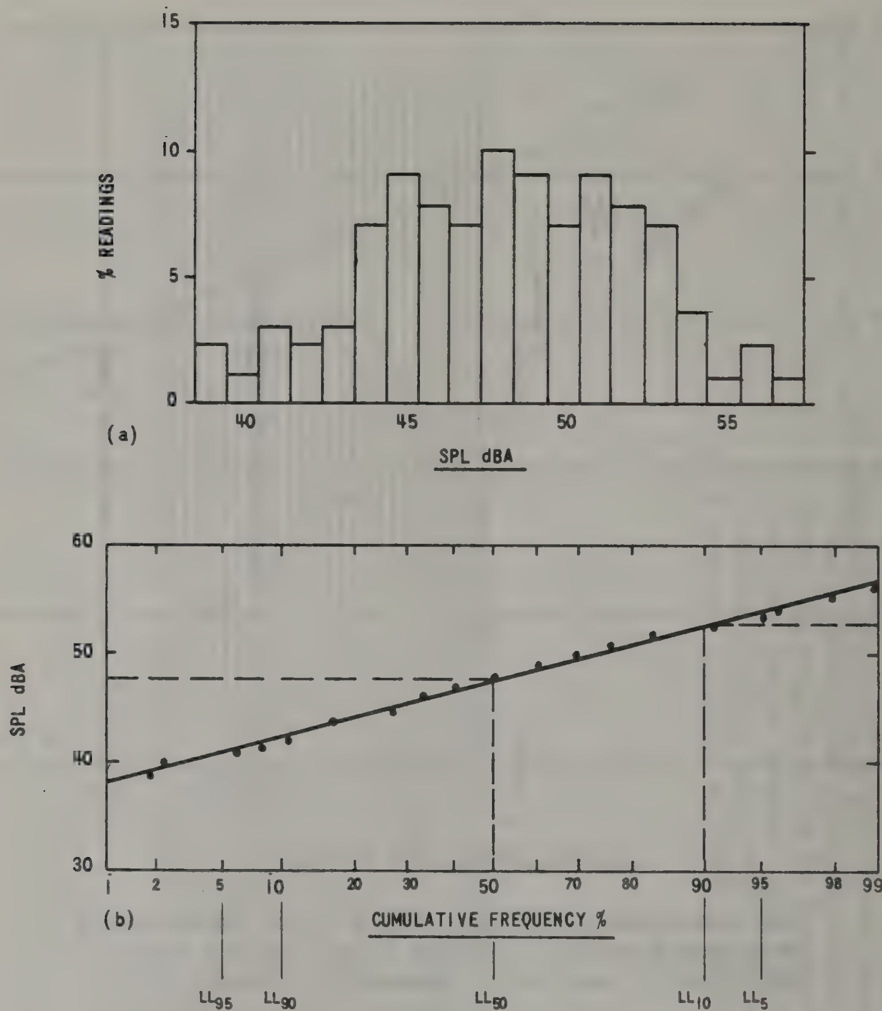


Fig. 5 Spot measurements of works noise level taken nightly at a point at the works fence over a period of one year.

The spot day to day measurements of works noise level at a particular location over a period can be plotted as a histogram (Fig.5a). For some purposes the cumulative frequency plot is more convenient (Fig. 5b). This shows the percentage of time that the level is below a given value and this is a simple method of obtaining a statistical view of environmental data (3).

From Fig. 5b, the 90 percentile level is 53 dBA; that is to say for 90 percent of the time the noise level is <u>below</u> 53 dBA.

The cumulative levels from 0 to 100% are commonly used for classifying environmental data. Unfortunately, in environmental noise analysis it is customary to refer to the proportion of the time that a given level is <u>exceeded</u>. Thus:

L_{10} denotes the level exceeded for 10% of the time (i.e. the 90% cumulative level).

L_{90} denotes the level exceeded for 90% of the time (i.e. the 10% cumulative level).

It is conventional to limit ambient noise L_{10} and L_{90} measurements to periods of up to 24 hours. This is because traffic, residential and commercial noise patterns tend to vary within a diurnal cycle and to be repeated day to day. The distant works noise level, however, is constant only as long as weather conditions remain constant and can vary widely from one to another. The cumulative levels shown in Fig. 5 therefore represent <u>long-term</u> values and we can denote them by the symbol LL. Thus:

LL_{10}: the level of works noise at a neighbourhood point which is exceeded for 10% of the whole year.

Etc.

<u>The downwind noise level</u> (L_{dw})

The paper by Gill and Large (4) deals with the physical aspects of propagation of noise through the atmosphere. The end result of these physical factors is the day to day variation in noise levels shown in Figs. 4 and 5.

Practical experience in neighbourhood noise measurement indicates that the most important single factor causing variation in noise propagation near to the ground is wind direction. Propagation is enhanced downwind and impeded upwind, and the downwind enhancement

effect appears to be greatest in light to moderate steady wind conditions. The average downwind noise level (L_{dw}) is generally equal to or greatest than the long-term 90% level (LL_{10}). Thus the L_{dw} is a measure of the worst conditions <u>likely</u> to be encountered.

The strength of the wind and other atmospheric conditions at the time of measurement have some effect, so L_{dw} varies to some extent. For noise record and assessment purposes it is necessary to find the average L_{dw} from readings taken on several different days.

One further point has to be made with regard to noise from continuous process plant which operates round the clock. During the day the noise may be drowned by traffic and "social" noise, and therefore it may be acceptable; but at night the noise may be far more prominent, and therefore unacceptable. In such a case it may well be impracticable to measure the works noise during the day (Fig. 2a), so measurements have to be made at night. If there is concern relating to noise at night some measurements will have to be made at night anyway, for two reasons. First, it is necessary to determine the noise "emanating from the premises" at night - as required by the Control of Pollution Act 1974. Second, atmospheric conditions, particularly with respect to temperature lapse rate, tend to be different at night and this may affect noise propagation and hence noise level in the neighbourhood.

5. THE NOISE MEASUREMENT REGULATIONS

The 1976 Noise Measurement Regulations (5), made under the 1974 Control of Pollution Act, specify how works noise is to be measured. The Regulations were designed primarily for dealing with factories situated in residential areas, in which case the noise levels are measured around the perimeter of the works. They recognise the importance of wind effects and specify the conditions under which noise level measurements should be taken.

The Regulations state that if the noise source is more than 50m from the measuring position, "a positive wind component of up to 2m/s towards the measuring position, to ensure that the measured noise level is at a maximum, is desirable" (Para. 12.2). So they are calling for the L_{dw}.

In the case of large process works - such as petrochemical plants, fertilizer works, steel works, oil refineries, power stations - the perimeter fence may be several hundred meters from the noise sources. In this case the L_{dw} at the boundary fence will be considerably higher than the average year-round level. (LL_{av} or LL_{50}).

Logistical implications of the Regulations

In addition to the "positive wind component of up to 2m/s", the Regulations make other provisos as to weather conditions. Measurements should not be taken "during conditions of temperature inversion, or in snow, rain or fog". Measurements cannot be taken in strong winds anyway because of the effects of wind on the microphone of the sound level meter. These are all reasonable requirements, but they do severely restrict the opportunities for taking valid measurements.

To estimate just how restrictive these requirements are, we need to be rather more specific. The minimum wind speed may be taken as 1.5m/s, since wind direction becomes indeterminate below this speed. Wind noise on the microphone becomes troublesome with wind speed above about 5m/s even when a wind-shield is used. "Temperature inversion" is not a precise term. Pasquil stability categories F and G indicate a very stable surface layer of the atmosphere, which is probably what is meant in this context. There is some overlap in these restrictions, since most periods of fog and of category G stability will be included in the periods of calm ($<$ 1.5m/s wind).

The result of these restrictions is as follows:

		%
Total time available:		100
Calm conditions - no wind (say $<$ 1.5m/s)	6%	
Wind noise on microphone (say $>$ 5m/s)	52%	58
		42
Rain ($>$ 0.1mm/h)	6%	
Inversion and/or fog (at night) and snow -	c.25%	14
		28
Wind in wrong direction (average)	50%	14
		14
Positive wind component $>$ 2m/s	66%	9
		5

Thus the specified conditions exist for only about 5% of the time; that is to say 18 days (or nights) in the year.

The night-time itself is likely to be more restricted than the 10pm-7am given in BS 4142. In any residential area there is likely to be a surge of traffic at closing time (say 10-11pm).

In the vacinity of a continuous process works there will be some traffic at or before the shift change (say 10-11pm and 5-6am). Thus the neighbourhood does not settle down until after 11pm and re-awakens by 5am.

The sound level meter measures ambient noise level, so works noise level in the neighbourhood cannot be measured reliably by automatic means. Judgement is required at the time of measurement to estimate whether it is being measured. The Regulations recognise this and the Government Circular (6) sensibly advised that "a representative of the occupier of the premises should have the opportunity to be present when measurements to be recorded in the noise level register are taken". (Para. 3.1.2).

If the local Environmential Health Officer and a representative of the works are to meet for the taking of measurements, and this is to be done after 11pm, then arrangements must be made beforehand on the basis of the weather forecast. Shortrange local forecasting is quite reliable, but suitable conditions occur only with light to moderate winds and wind direction forecasting is generally less reliable under light wind conditions.

Even under the restricted weather conditions specified there will be considerable day to day differences in noise levels at distances of several hundred metres. It is therefore important to take the average of several - at least three - sets of noise readings on different days. If two or more measuring locations in widely different directions from the works are used, different wind directions are required for downwind measurements to be taken at each location, so two or more different days are involved in taking just one complete set of readings. Thus the determination of valid neighbourhood noise levels remote from a works is a process which requires patience, planning and probably some months of elapsed time.

These comments are not intended as a criticism of the Regulations. This is a good document which faces the problems honestly and is, as far as the author knows, in advance of any statutory regulations in any other country in the world. We just have to accept that valid measurement records of noise from distant works cannot be obtained easily or quickly.

Less restrictive measurement requirements

It would be helpful if the weather conditions for measurement could be made less restrictive. The wording of the Regulations is not

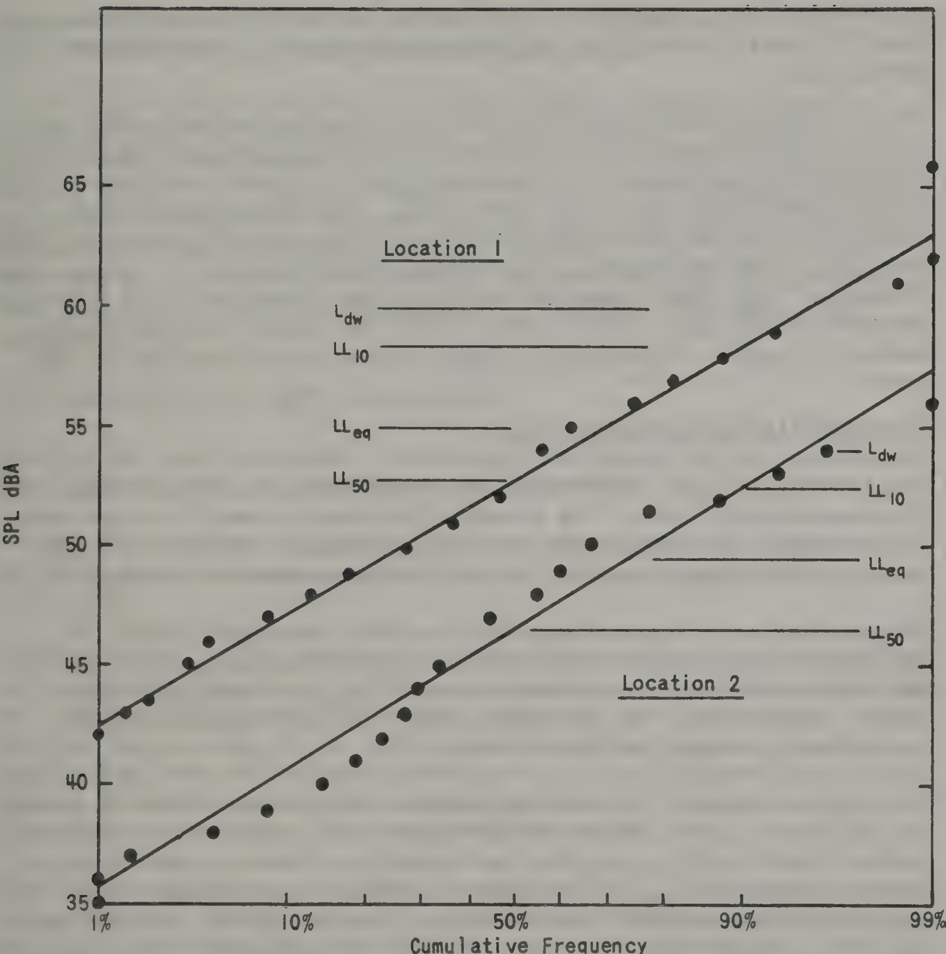


Fig. 6 Cumulative frequency plot of works noise levels measured nightly at two locations. (Location 1 is the point at which the records in Fig. 2 were taken).

completely categorical. It recommends rather than requires the conditions to be met, so it presumably leaves some opportunity for discussion and agreement between works and authority in any particular area.

A simple wind speed limit of 5m/s maximum rather than the wind speed component of 2m/s would make many more occasions available. With regard to inversions, this again is a matter of degree. It seems likely that only severe inversions are significant and

these occur only with very light winds. A limiting condition of Pasquil class G stability would be more specific and far less restrictive.

Fig. 5 uses genuine field data but this example was selected to show a fairly symmetrical histogram and a close approximation to a straight-line cumulative frequency plot. Fig.6 shows more typical data from two other locations. The approximation to straight lines is good enough for LL_{10}, LL_{50} and LL_{90} values to be read off. The approximate mean downwind level (L_{dw}) is shown also. "Downwind" here was taken as the situation where the wind direction was within 45° each side of the line from a major source to the measuring point. There were several major noise sources in the works.

The equivalent noise level, L_{eq}

Environmental noise is never quite constant, its level varies or fluctuates with time. The average (arithmetic mean) is not very satisfactory for assessment of varying noise. The peak levels have a considerable bearing on the intrusiveness of noise.

The decibel is a logarithmic unit, so the "average" level of varying noise is best taken as the logarithmic mean. This is the equivalent continuous noise level (L_{eq}). The L_{eq} is the steady noise which has the same energy content as the varying noise over the same period of time.

The L_{eq} is relevant to hearing damage risk because hearing damage is related to total noise energy dose; but there is no fundamental reason why L_{eq} should be directly related to annoyance by noise. However, L_{eq} is influenced strongly by the peak levels and lies somewhere between the arithmetic average level and the peak so it is probably more closely related to annoyance than the average level. The Noise Advisory Council advocates the use of L_{eq} for assessing environmental noise (12).

In measuring environmental noise, the L_{eq} is generally taken over a period of some hours (such as 10pm - 6am, or 24 hrs.). If the noise fluctuates about a generally constant level it is adequate to take the L_{eq} of a short "sample" of the noise, provided the sample period covers a representative period of fluctuation. In this case the time may be only a few minutes.

The Regulations call for L_{eq} values. If the measured level varies little, say no more than 5 dBA, the average or most common level would be close to the L_{eq} and more detailed analysis is not re-

quired. If downwind noise levels only are measured, each L_{dw} value is a short-term L_{eq} under downwind conditions.

If the L_{dw} from a continuous process works is measured several times during the same night under steady weather conditions, the variation in measurements would normally be small and the average may be taken. If this is repeated on say three different nights, again the average may be taken - it is not realistic to distinguish between arithmetic and logarithmic means of three data points. Thus the LL_{dw} is really the average of several L_{dw} measurements, each of which should be an average of several short-term L_{eq} measurements.

6. ASSESSMENT OF WORKS NOISE LEVEL

Having, at last, measured the works noise level in the neighbourhood, we now have to assess its acceptability.

The BS 4142 method is appropriate both for assessing noise from existing works and for setting limits for new works (7) (8) (9) (10) (11).

At first sight one would say that the works noise level should be below background level. BS 5142 indicates that there is some risk of complaints against an existing works if they are equal. For a planned new works, if the works noise is equal to background it would seem that the ambient level should rise by 3dBA (the normal result of adding two equal levels) and this is the creeping increase situation which Planning seeks to avoid.

This would be the case if the "background" and "works" noise levels were measured in the same way, but they are not. The background level called for by BS 4142 is the L_{90}, which means that background noise actually is above this measured level for most (90%) of the time. The works noise level is the L_{eq} and the Standard implies that where this varies because of weather effects a typical level should be used.

With distant works, the Regulations call for the L_{dw} and it is both reasonable and convenient to use this for assessment purposes. But the L_{dw} is far from a "typical" level, it is a level which is equalled or exceeded for probably less than 10% of the time.

Thus if "works noise level" (L_{dw}) equals "background noise level" (L90), the actual works noise level at any moment will exceed the background at that moment for not more than 10% of 10% i.e. 1%

of the time. In other words, if works noise level and background noise level are nominally the same, works noise level is in fact below background for 99% of the time. This is not the situation for which BS 4212 was designed.

The Noise Advisory Council advocates the use of L_{eq}. The Dept. of the Environment Manual (8) and the Planning Circular (7) advocate use of BS 4212. Therefore it would be appropriate to obtain the long-term L_{eq} (LL_{eq}) for the distant works and to use it in BS 4212. It is difficult enough to obtain a reliable L_{dw}, and the programme to obtain an LL_{eq} is necessarily much longer (13a). Indeed, it may be impossible to obtain a true LL_{eq} as the works may be inaudible for much of the year.

A solution is to derive and standardise a factor relating L_{dw} to LL_{eq}. Then we can measure L_{dw} and apply the factor to derive a notional LL_{eq}. This LL_{eq} could then be used as the works noise level in applying BS 4142.

This is not entirely novel in concept. BS 4212 already accepts the use of a notional background level if the background noise alone cannot be measured directly. There is good evidence to support the use of notional reference levels rather than actual background levels for assessment of community reaction (14).

The 1978 draft revision to ISO 1996 (15) introduces the long-term L_{eq}, and recognises that this may have to be a notional value based on L_{dw}. The German draft standard VDI 2714 (16) contains a graph relating maximum, mean downwind, long-term equivalent and minimum levels to distance from the works. This indicates that LL_{eq} is about 2dB below L_{dw} (night) for distances greater than 500m. The author's experience indicates that LL_{eq} is typically 5dB below L_{dw} (Fig.6). As yet there is very little published data on which to base a confident estimate.

7. CONCLUSION

The established methods of assessing community response to industrial noise, BS 4142 & ISO R1996, are based on the traditional situation where factories exist close to housing in industrial towns or in villages. Large modern process works are now often located in rural or semi-rural areas where background noise levels are low, and works noise may be intrusive at a considerable distance from the works. The BS and ISO methods are not applicable to this situation as they stand because they do not deal adequately with the day to day variation in noise level from a distant works

caused by varying weather conditions.

This problem affects all the major process industries. The oil industry is devoting some effort to finding solutions. Several papers have been published in the areas of (a) noise assessment (10) (11) (13) (17) and (b) noise predicting and noise control design (18) (19) (20) (21) (22) (23) and CONCAWE has a further programme of work in hand on noise propagation (24) (25).

This paper offers suggestions for making progress on two aspects of the problem:-

(i) standardised, but not too restrictive, conditions for taking noise level measurements.

(ii) The use of these measured levels in the application of the BS 4142 assessment method.

There is much more still to be done. Continued effort and co-operation between industry, control authorities, research institutes and standards bodies is required to derive and agree on more reliable methods of prediction and assessment of noise at a distance from industrial works.

8. ACKNOWLEDGEMENT

The author is indebted to Esso Petroleum Co. for permission to publish this paper, to his colleague H.I. Fuller for advice and others on OCMA and CONCAWE committees for ideas. The opinions expressed in this paper are not necessarily those of Esso or the other organisations.

REFERENCES

(1) BS 4142 Method of rating industrial noise affecting mixed residential and industrial areas (1967) with amendment AMD 1661 (1975) BSI London.

(2) Schreiber L. Noise around large open industrial plants. Internoise (Copenhagen).

(3) Sutton P. Protection Handbook of Pollution Control*

(4) Gill H.S. and Large J.B. Factors affecting environmental sound propagation. Clean Air Conference, Scarborough 1979. NSCA, Brighton.

(5) SI No. 37.1976. The Control of Noise (Measurements and Registers) Regulations. HMSO.

(6) Dept. of Environment Circular 2/76. Control of Pollution Act 1974. Implementation of Part III - Noise. HMSO.

(7) Dept. of Environment Circular 10/73. Planning and Noise. HMSO.

(8) Dept. of Environment. Research Report No.13. Assessment of Major Planning Applications. DoE 1976.

(9) Sutton P. Protection Handbook of Noise Control (3rd ed)*

(10) Sutton P. Noise and the community. Annals Occup. Hyg. 1971 XIV (109-117).

(11) Community response to refinery noise (1972) Stichting CONCAWE The Hague.

(12) Noise units. Noise Advisory Council (1975) HMSO.

(13a) Sutton P. L_{dw} or LL_{eq} - IOA (Southern Branch) Conference - Statistical aspects of Outdoor Noise Propagation 1978.

(13b) Sutton P. Neighbourhood noise assessment - do we need a long-term L_{eq}?. Proc. Inst. of Ac. 1978. (16.2.1-4)

(14) EEC. Damage and annoyance caused by noise (1975) EUR 5398e CEC Luxemburg.

(15) ISO R1996 (1971) Assessment of noise with respect to community response. Draft Revision DP 1996/1 (1978)

(16) VDI 2714 (1976) Draft. Schallansbreitung in Freien (Sound propagation in the open).

(17) Sutton P. Community response to oil refinery noise. 8th Int. Congress on Acoustics (London) 1974 (124).

(18) Sutton P. The design of a noise specification for process plant. J. Sound Vib. (1968) VIII (33-43).

(19a) OCMA. NWG-1 (Rev.1) Procedural specification for limitation of noise (1972) Oil Companies Materials Assocn. London.

(19b) OCMA NWG-3 (Rev.1) Guide to NWG-1.

(Note: Major revisions of NWG-1 and NWG-3 are in hand - 1979).

(20) Middleton A.H. and Seebold J.G. Propagation of machine generated sound within and around a process plant. Internoise (Washington) 1972.

(21) Marsh K.J. Specification and prediction of noise levels in oil refineries and petrochemical plants. App. Ac. (1976) IX (1-16).

(22) Sutton P. Process plant noise - evaluation and control. Ibid (17-34)

(23a) Determination of sound power levels of industrial equipment (1976). Stichting CONCAWE. The Hague.

(23b) Measurement of vibration complementary to sound measurement (1977) Ibid.

(24) Study of noise propagation by Acoustic Technology Ltd. Southampton for Stichting CONCAWE, The Hague (in progress 1979).

(25) Manning C.J. An engineering approach to the prediction of ground and meteorological effects on sound propagation from industrial complexes. Proc. Inst. of Ac. 1978 (16.1.1-4).

* obtainable only direct from the publishers Alan Osborne (Books) Ltd. Unit 5, Seagar Buildings, Brookmill Road, London SE8. Prices incl. p&p. Noise Handbook £1.25. Pollution Handbook £1.50.

NATIONAL SOCIETY FOR CLEAN AIR

46th ANNUAL CONFERENCE
15-18 OCTOBER 1979
SCARBOROUGH

THE ACCURACY, INTERPRETATION AND USE OF RESULTS OBTAINED FROM MONITORING AND MEASUREMENT OF AIR POLLUTION

by

Dr. M.J.R. Schwar,
Greater London Council, Scientific Branch

National Society for Clean Air
136 North Street
Brighton BN1 1RG
England

1. INTRODUCTION

We all come into contact daily with a whole range of air pollutants and judgements are having to be made by planning authorities as to whether exposure to these pollutants is acceptable.

The Greater London Council (GLC) is just one of many bodies having to choose between various courses of action depending, amongst other things on air pollution considerations. This paper gives a snapshot picture of a number of pollution exposure situations of interest to the Council in its day-to-day work. While instrument accuracy is referred to, rather than dwell overmuch on this aspect, attention is focussed in the main on how well monitoring procedures describe people's exposure, bearing in mind that they may come into contact with a variety of sources of pollution during their daily activities. Numerous examples of measured pollutant concentrations are given to illustrate how pollutant concentrations can vary with time and from place to place. These are discussed under three headings. The first deals with exposure to sulphur dioxide and smoke, the second with exposure to traffic pollution, and the third with a variety of other pollutants and sources of pollution.

To help judge the significance of measured pollutant concentrations a number of air quality criteria are drawn upon. Many of these criteria have been formally adopted by the GLC as Air Quality Guideline Concentrations (1) to assist it in the consistent interpretation of pollutant levels. If it is found that people, especially susceptible people such as the very young or elderly, are likely to be repeatedly exposed to concentrations above the guideline level, there may be grounds for concern over the possible effects that exposure may have on their health. But, in considering these consequences, we would also examine the wider medical effects as well as the related social and economic implications.

Some examples of practical uses to which air pollution monitoring has been put in recent years include:

- assessing present-day levels of sulphur dioxide and smoke in relation to the World Health Organisation (WHO) Expert Committee's long-term goals for urban environments, and in relation to possible European Health Protection Standards;

- assessing road traffic pollutant concentrations as a first step in selecting the most appropriate traffic management option, or towards providing an environmental overview in assessing a new road scheme;

- providing a data base, for example, on local carbon monoxide concentrations as a first step in judging the total exposure of people at the roadside, in road tunnels, in enclosed car parks, and in the home;

- following changes in pollutant levels, for example, of sulphur dioxide and background smoke concentrations, over a period of time;

- providing information for planning or design purposes, for example, for the assessment of the suitability of land for housing or for the location of a playschool.

These examples probably also represent a cross-section of activities of interest to many other local authorities, and a number of them are now discussed in a little more detail.

2. EXPOSURE OF PEOPLE TO SULPHUR DIOXIDE AND SMOKE IN LONDON

Sulphur dioxide and smoke concentrations vary greatly across London. Differences as large as a factor of 2 or 3 have been observed at points less than 500m apart. This makes it difficult to define pollutant concentrations over extended areas, and to compare pollutant levels in different towns and cities. The picture one builds up depends very much on the number and distribution of monitoring sites. Data from a few sites can be helpful for indicating the intensity of, say, a pollution incident, but for the reasons mentioned they are unlikely to reflect the severity of the incident in terms of the exposure of people, or even the area in which concentrations reach critical proportions. Table 1 compares the highest concentrations recorded in a pollution incident in 1975 with levels recorded during the 1952 London smog. Concentrations shown are of the highest readings (2,3) recorded on each day of the incidents. The smoke data for 1952 are reported values and are probably a significant under-estimation of the true levels (4) (possibly by as much as a factor of 2). Nowadays the levels of pollution are commonly much lower than they used to be, but they are still some way above the levels recommended in 1972 by an Expert Committee of the World Health Organisation (WHO) as Long Term Goals (5) for air quality in urban environments. In the 'fifties the critical level in London was thought (6,7) to be reached when the mean daily concentrations (averaged over 7 sites) were 2000 $\mu g/m^3$ for smoke with 0.4 ppm (i.e., about 1000 $\mu g/m^3$) for sulphur dioxide. More recently it has been stated (5) that an excess mortality in the general population may occur when the

levels of suspended particulates and sulphur oxides both exceed 500 $\mu g/m^3$. (The terms smoke and suspended particulates are sometimes used loosely to mean the same thing. However, they are not equivalent as the concentration of the first is estimated from the blackness produced by suspended matter trapped on a filter paper through which air is drawn, while the second is equal to the actual mass of particulate matter in a given volume of air). The aggravation of the condition of bronchitic patients appears to be associated with pollutant concentrations of 250 $\mu g/m^3$ for smoke and 500 $\mu g/m^3$ for sulphur dioxide occurring together over 24 hours. It would appear from Table 1, therefore, that some people may still be adversely affected by this kind of pollution. In the past, adverse health effects have been observed mostly in susceptible groups of the population, namely those with cardiac or pulmonary disease, and bronchitics. However, death was thought likely to occur only in patients whose life expectation, even in the absence of pollution, was very short. Also, it should be noted that smoke and sulphur dioxide may not be the only factors contributing to the observed adverse health effects. Social and occupational influence may be important, as may associated periods of cold and the presence of other pollutants such as sulphur trioxide and acid mist, and carbon monoxide. The presence of vanadium compounds has also been suggested (2) as a possible contirbuting factor.

In 1976 the Commission to the Council of the European Communities proposed (8), for discussion amongst Member States, health protection standards for suspended particulates and sulphur dioxide. In the opinion of the Commission exposure of the population to concentrations above the proposed limits would constitute an unacceptable hazard to health. The levels currently being discussed are above those recommended by the WHO Expert Committee as long-term goals. The current European Commission's proposal and the WHO goals are as follows:

<u>European Commissions' proposed Health Protection Standard for Particulates and Sulphur Dioxide</u>

(a) Daily mean concentrations of particulates and sulphur dioxide not to exceed 250 $\mu g/m^3$ for more than 7 days/annum unless the daily mean concentration of particulates is less than 100 $\mu g/m^3$ when the concentration of sulphur dioxide is not to exceed 350 $\mu g/m^3$.

(b) Winter median values of daily mean particulates and sulphur dioxide not to exceed 130 $\mu g/m^3$ unless the median value of

particulates is less than 60 $\mu g/m^3$ when the median value of sulphur dioxide is not to exceed 180 $\mu g/m^3$.

(c) Annual median values of daily mean particulates and sulphur dioxide not to exceed 80 $\mu g/m^3$ unless the median value of particulates is less than 40 $\mu g/m^3$ when the median value of sulphur dioxide is not to exceed 120 $\mu g/m^3$.

WHO Expert Committee's recommended Long-Term Goal for Particulates and Sulphur Dioxide

(a) Daily mean concentrations of particulates not to exceed 120 $\mu g/m^3$ and of sulphur oxides not to exceed 200 $\mu g/m^3$ for more than 7 days/annum.

(b) Annual mean concentrations of particulates not to exceed 40 $\mu g/m^3$ and of sulphur oxides not to exceed 60 $\mu g/m^3$.

These criteria are based on particulate concentration estimates made from the measurement of the darkness of a stain on a filter paper through which a known volume of air has been drawn. The criteria, therefore, are really smoke concentration criteria rather than total suspended particulate criteria. The Greater London Council in 1975 formally adopted (1) air quality guideline levels for suspended particulates (smoke) and sulphur dioxide which are based on these WHO long-term goals. The WHO also recommended that progress made towards achieving these goals should be periodically reviewed in the context of socio-economic developments and other public health problems.

The G.L.C., as a strategic planning authority, has responsibility (9) to see there is no overall deterioration in London's air, and where possible to ensure that improvements take place. An estimate of the extent to which people are exposed to smoke and sulphur dioxide in London may be made from an examination of the daily readings recorded at more than 125 National Survey of Air Pollution monitoring sites. These sites are operated by 33 local government and other authorities and provide the most comprehensive data set available on these pollutants. Unfortunately the location of many of the sites do not necessarily reflect concentrations to which people are exposed. However, this is probably less serious as regards exposure to sulphur dioxide than to smoke. Nevertheless, these limitations ought to be borne in mind when applying the results of the analysis.

The number of National Survey monitoring sites in Greater London

in 1975/6 was 134. There were distributed over 1600 km^2. Sites tend to be more concentrated in areas of high sulphur dioxide pollution. They are, perhaps not surprisingly, also more concentrated in areas of high sulphur dioxide emission (10) - see Table 2. The mean area per monitoring site in the central part of London is under 2 km^2 while in the less sulphur dioxide polluted outer part it is almost 50 km^2. Table 3 shows the median values of the annual mean smoke and sulphur dioxide concentrations for all sites for a number of years. Figure 1 shows the per centum of sites which do not meet the WHO long-term goals for recent years. The area of London not meeting these goals could be calculated knowing the distribution of pollution levels over the area. But, all that is known is the distribution of pollution levels at a number of points.

An approximate estimate, based on a knowledge of the distribution of sites in relation to the distribution in sulphur dioxide emissions given in Table 1, suggests that in 1976/7 about 1000 km^2 of London exceeded the WHO long-term goal of 60 $\mu g/m^3$ (annual mean) and over about 100 km^2 twice this level was exceeded. For comparison, the estimates for 1977/78 are 600-700 km^2 and 10-15 km^2 respectively. More accurate estimates could be made taking into account contributions from the larger individual sources. Similar estimates for smoke have not been made as there is no obvious relation between the distribution of the monitoring sites and sources of smoke emission, which in London now seem to come mainly from road traffic (11).

3. EXPOSURE OF PEOPLE TO ROAD TRAFFIC POLLUTION IN LONDON

Probably there are now more people exposed to traffic, and there are more people concerned over the effects of traffic pollution than at any other time. Unfortunately, there are no extensive data on historical changes in roadside pollution levels as there are for background smoke and sulphur dioxide levels. Nevertheless it does seem likely that roadside pollution levels in the very heavily trafficked areas of central London have not changed appreciably over recent years, but in the intermediate and outer areas of London levels have probably increased along with increases in traffic density.

Traffic smoke is still a nuisance, as it was 25 years ago (12). Levels of carbon monoxide (from barely detectable to average concentrations of perhaps 15-20 mg/m^3) and of lead in the air (annual mean of 1-3 $\mu g/m^3$), reported 10 years ago by a WHO Expert Committee on Urban Air Pollution (13) as occurring in urban areas

in several countries, are very much the same as the levels recorded in London today.

People's exposure to traffic takes many forms, but usually it seems to be the effects of noise and air pollution which cause greatest concern. There are, however, many other aspects of vehicle intrusion which can cause annoyance and these too should be considered when carrying out an environmental assessment of a road scheme or traffic management measure. They include: traffic-generated dirt and smells; airborne and groundborne vibration; proximity of traffic to people and property or sensitive areas; visual intrusion; and the physical volume of traffic. The relative importance of each of these aspects of exposure will vary from place to place and no one can be used as a surrogate for the others. In many instances it has been found that there is no evidence of dangerously high levels of air pollution but still people complain. These complaints need to be carefully examined for unless there is an appreciation of the total exposure problem any assurances that there are no health problems may well be treated with scepticism and suspicion.

There are established procedures for predicting road traffic noise levels. The Department of the Environment's method (14) is based on estimates of traffic flow, speed and composition as well as geometric considerations. Although the method may suffer from some technical shortcomings the procedure developed does allow a consistent basis for the evaluation of road schemes and traffic management measures. Unfortunately, no equivalent procedure exists for predicting roadside air pollution levels and until there is, it will continue to be necessary to rely upon the results of air pollution monitoring. For new road schemes likely pollution levels may be estimated from a knowledge of measured pollutant concentrations along similar existing roads. In the case of traffic management schemes air pollution measurements can be carried out before and after an experimental period prior to deciding whether it should be made permanent.

Roadside pollutant concentrations can vary greatly from day to day, and indeed from minute to minute, and in characterising these concentrations it is necessary to carry out the monitoring over a sufficiently long period of time to build up a representative picture of the long-term situation. Table 4 summarises the results of some measurements of short-term and long-term average concentrations of carbon monoxide recorded close to a heavily trafficked road carrying a 2-way traffic flow of about 40,000 vehicles per 24h in central London. The significance of these results may be gauged

by comparing the measured values with the GLC's guideline levels, based on the WHO long-term goals, and which are:

<u>GLC Air Quality Guideline Level for Carbon Monoxide</u>

(a) Eight hourly mean concentration of carbon monoxide not to exceed 10 mg/m^3;

(b) One hourly mean concentration of carbon monoxide not to exceed 40 mg/m^3.

Table 5 summarises the results of some airborne inorganic lead measurements made close to the same road. The GLC's guideline level for this pollutant, based on an estimate (15) of the lead-in-air concentration which when inhaled by a child could give rise to an elevation in blood-lead level of about 5 μg/100 ml, is

<u>GLC Air Quality Guideline Level for Airborne Inorganic Lead</u>

Three monthly mean concentration of airborne inorganic lead not to exceed 3 $\mu g/m^3$.

As the length of the monitoring period increases so the measured mean value approaches the true long-term mean. Table 6 illustrates the connection between measured means based on various monitoring periods. The source data for this table comprised mean daily carbon monoxide readings recorded over a period of 24 months. A similar dependence between long and short-term means has also been observed for lead-in-air. As an example, the table shows that a mean pollutant concentration based on measurements made over a period of only one month could be associated with a long-term mean of anything between -30% and +40% of the measured mean. Because of this, every effort is made to ensure that measurements are carried out for periods of at least 3 months whenever possible.

The fact that air pollution monitoring normally needs to be carried out over quite long periods of time, and requires relatively costly equipment, places severe constraints on the number of monitoring sites that can be set up. As an example, in a recent study along a 5 km stretch of road 3 sites have been installed. The placement of the sites is, of course, important and must take into account the location of sensitive areas. These may include: highly congested residential and shopping areas; schools; hospitals; play areas, and allotments. A basic difficulty in building up an accurate picture of pollution levels along a road in this kind of study is the extrapolation of data recorded at a limited number of points.

Towards solving this problem procedures are being developed to identify those stretches of road along which traffic emissions are likely to be greatest and, perhaps more importantly, to quantify the relative distribution in these emissions.

Figure 2 shows the estimated distribution of carbon monoxide emissions along a 2 km stretch of road. The levels shown relate to the mean hourly emission rate over the most heavily trafficked 8 hour period of the day. The construction of this pollution map is based on measurements of traffic flow and speed to give a point by point distribution of vehicle density along the length of road (i.e., the number of vehicles per unit length of road). This is then multiplied by an appropriate mean emission rate to give an emission density expressed in terms of mass of pollutant emitted per unit time per unit length of road. Also shown in the figure is the position of the roadside monitoring site. If the assumption is made that to a first approximation roadside pollution levels are proportional to the emission density, pollution maps may be used to scale pollutant concentrations measured at a point up or down, as necessary, along the whole length of the road. There is some evidence to support this procedure. We have re-examined several years' data on our files of measured roadside pollutant concentrations and have found a fairly good association between long-term mean concentrations and estimated mean traffic densities (based on traffic flow records and retrospective estimates of traffic speed) - see Figure 3. This approach for characterising road traffic pollution is still in its early stages, but its predictive capabilities make it a potentially powerful tool for environmental impact studies.

4. EXPOSURE OF PEOPLE TO OTHER POLLUTANTS AND OTHER SOURCES OF POLLUTION

During the course of a day each one of us may be exposed to many other pollutants and other sources of pollution in addition to the ones already mentioned. It is important that as many as possible of these sources of exposure be taken into account if we are to assess the total pollution burden to which we may be subjected.

Lead-containing particles emitted from motor car exhausts and lead smelting and other works may be ingested as well as inhaled. The initially suspended lead aerosol will eventually settle on various surfaces and may then enter the body via the contaminated surface-hand-mouth route (16). Also, the lead aerosol may deposit on food and utensils used for the preparation of food and this too may add

directly to the dietary lead burden (17). It would seem that the intake from each or all of these routes in combination could add to the net lead burden of people and for some, especially children, this might be significant. Ingestion from this source must, of course, depend critically on personal and kitchen hygiene habits.

Paint is another obvious potential source of lead, particularly paint on toys and pencils. It should be remembered, however, that usually the most important single source of lead is that which is found in food and in some areas also in tap water.

There are no guideline levels against which to judge environmental lead deposits. Lead in paint regulations require that total lead concentrations used on toys (18) should not exceed 2500 ppm and soluble lead used in pencils (19) should not exceed 250 ppm. In practice most paints for toys tested in the UK rarely exceed 100-200 ppm (20).

Lead in food regulations (21) require that no food should be offered for sale (other than a few specified exceptions), with lead levels greater than 2 ppm. Lead in food (22) specially prepared for babies or young children should not exceed 0.5 ppm. Recommendations have been made (23) to further reduce both these limits. The mean lead content of the total diet (24) in the UK has been estimated to be 0.13 ppm. There is some evidence (24) which suggests that certain food crops (e.g., lettuces) grown 15m from a very heavily trafficked road may acquire surface lead deposits sufficient to give rise to total levels in excess of these values.

One way of characterising deposited dust is in terms of the total amount of inorganic lead present in a sample of dry dust or dirt. There are no widely accepted standardised procedures for the collection, preparation and analysis of samples, but it is our practice to analyse only those particles which pass through a 500 µm sieve. Replicate sampling on different occasions have given rise to lead levels which differ by a factor of two, although replicate sampling at the same time of apparently identical dust deposits often agree to within ± 100 ppm. Levels can vary considerably from place to place along a given stretch of road - see Table 7.

Black smoke is one of the more obvious aspects of traffic pollution, especially that emitted from diesel engined vehicles. It has been the source of much public annoyance over the last quarter of a century (12) and must contribute appreciably to the soiling of building fabrics, soft furnishings and clothing. Unfortunately,

there is, as yet, no simple way of characterising this soiling propensity of traffic smoke. The reflectance method of determining the concentration of smoke in air in terms of an apparent concentration of a standard smoke does, however, given an index of the amount of black matter in the air. The elevation in smoke levels found close to a heavily trafficked road in central London (40,000 vehicles/24h, 30% diesel engined vehicles) is illustrated in Table 8. These roadside measurements were made 6m above and 10m back from the kerbside. Kerbside levels will, of course, be even higher.

Two other pollutants to which people are frequently exposed are nitric oxide and nitrogen dioxide, often referred to together as oxides of nitrogen or NO_x. Of the two, nitrogen dioxide is potentially the more toxic. A WHO Task Group have proposed (25) the following environmental health criterion consistent with the protection of public health:

WHO Task Group's proposed Environmental Health Criterion for Nitrogen Dioxide

One hourly mean concentration of nitrogen dioxide not to exceed 190-320 ug/m^3 more than once per month.

Exposure to nitrogen dioxide can occur at the roadside, or indeed wherever motor vehicle engines are running. There is the possibility of exposure to this gas wherever one comes into contact with the products of combustion, especially from unflued appliances including domestic combustion appliances. Table 9 lists a number of measured levels of nitrogen dioxide recorded at roadside and non-roadside situations.

Oxides of nitrogen can react chemically, under the action of bright sunlight with hydrocarbons, oxides of sulphur and various trace chemical species present in the air to form what is known as photochemical pollution. Exposure to this form of pollution used once to be associated mainly with Los Angeles but today it is recognised that it can also occur in London under certain meteorological conditions. The most familiar component of photochemical pollution is ozone and the GLC's guideline level for this pollutant is:

GLC Air Quality Guideline for Ozone

One hourly mean concentration of ozone not to exceed 160 μg/m^3.

Table 10 summarises the results (27) of some ozone measurements

made in Greater London in recent years. There are, however, wider considerations than just health. For example, elevated ozone levels have been associated with the formation of summertime urban haze (28) or photochemical smog. Material damage can also occur, such as the cracking of rubber.

Carbon monoxide is the most abundant of the potentially toxic air pollutants. It sometimes seems also to be the most forgotten. Motor vehicle emissions account for almost a million tonnes of carbon monoxide discharged into London's air each year. Exposure of people is not, however, confined to outdoor roadside situations. By far the most severe single source of exposure is through smoking, but there are also many other situations where many of us may come into contact with high levels of carbon monoxide for short and occasionally long periods of time. The use of air quality criteria to judge pollution levels at a point can give a misleading picture of a person's body burden if attention is confined solely to isolated measurements.

The USA National Ambient Air Quality Standards (29) for carbon monoxide are designed to protect against the occurence of blood - CO levels above 2% COHb. This compares with the WHO Expert Committee's statement (5) that there is general agreement that people should be protected against continuous levels of 4% COHb or over. Above this level there appears to be increased risk for patients with cardiovascular disease. The WHO Long-Term Goals for carbon monoxide are equivalent to the USA Air Quality Standards. Table 11 lists some carbon monoxide levels recorded at a number of roadside and non-roadside situations. Figure 4 shows examples of calculated elevations in blood-CO following exposure to several sources of high carbon monoxide levels during the course of a day. It is apparent that non-roadside sources, including non-flued domestic combustion appliances, may contribute significantly to the estimated elevations in blood-CO in the examples given.

5. IN CONCLUSION

It is hoped that the picture that has been built up has thrown some light on how the GLC is coping with the problem of characterising and interpreting air pollution data. Each one of us experiences our own air pollutant burden and this depends intimately on the life-style we lead. Pollution control measures, however, cannot take such an infinite variety of possibilities into account. Controls have to be implemented locally, and so criteria for control

have also to be applied locally. In setting these criteria the possibility of exposure to other sources at other locations must, of course, also be recognised.

The Fifth Royal Commission on Air Pollution recommended the setting up of air quality criteria at two levels. It is suggested that the lower level should represent an approach to an ideal situation which if satisfied would mean that further controls would normally be unwarranted. The upper level would represent a critical level which, if exceeded, would demand some action to improve the quality of the environment.

It has been mentioned that there is some move in Europe towards such a standard for sulphur dioxide and smoke in urban environments. There are, however, many other pollutants and situations for which there are no criteria. For example, in the UK we have no criteria against which to judge carbon monoxide levels in road tunnels, in enclosed car parks, and in the home; we have no criteria for exposure to environmental lead; and there are no criteria to judge environmental exposure to the many other air pollutants not mentioned, for example, asbestos fibres, cadmium, fluorides, hydrocarbons and peroxyacetyl nitrate. Without these criteria planning authorities like the GLC must make their own individual judgements of whether exposure to a given pollutant concentration is acceptable.

6. ACKNOWLEDGMENTS

The author wishes to acknowledge the helpful comments from Dr. S.W. Radcliffe and the generous assistance provided by all his colleagues in the Air Pollution Section of the Environmental Sciences Group in the preparation of this paper, which is presented by permission of Mr. R.T. Kelly, Scientific Adviser to the GLC. The views expressed are those of the author and are not necessarily those of the Greater London Council.

REFERENCES

1. Greater London Council Joint Report of the Planning Committee and Public Services Committee, 'London's Air - Guideline Concentrations, Council Minutes, July 22, 1975.

2. Ministry of Health. Reports on Public Health and Medical Subjects No. 95. Mortality and Morbidity During the London Fog of December 1952. Her Majesty's Stationery Office, London. 1964.

3. Department of Industry. The High Pollution Episode in London, December 1975. A.J. Apling, A.W.C. Keddie, M-L.P.M. Weatherley and M.L. Williams. Warren Spring Laboratory, LP 263 (AP), 1977.

4. Ministry of Technology. Warren Spring Laboratory. The Investigation of Atmospheric Pollution 1958-1966. Thirty-Second Report. Her Majesty's Stationery Office, London. 1967.

5. World Health Organisation Expert Committee. Air Quality Criteria and Guides for Urban Air Pollutants. Technical Report Series: No. 506 Geneva, 1972.

6. J.A. Scott. The London Fog of December 1957. The Medical Officer, pp 367-8. 20 June 1958.

7. J.A. Scott. Fog and Atmospheric Pollution in London, Winter 1958-59. The Medical Officer, pp 191-3. 16 October 1959.

8. Official Journal of the European Communities. Proposal for a Council Directive concerning Health Protection Standards for Sulphur Dioxide and Suspended Particulate Matter, 19 March 1976.

9. Greater London Development Plan. Notice of Approval, Written Statement etc. Approved by the Secretary of State for the Environment on 9 July 1976. Available from GLC Bookshop, The County Hall, London, SE1 7PB.

10. D.J. Ball and S.W. Radcliffe. An Inventory of Sulphur Dioxide Emissions to London's Air. GLC Research Report 23, 1979. Available from GLC Bookshop, The County Hall, London SE1 7PB.

11. D.J. Ball and R. Hume. The Relative Importance of Vehicular and Domestic Emissions of Dark Smoke in Greater London in the Mid-1970s, the Significance of Smoke Shade Measurements, and an Explanation of the Relationship of Smoke Shade to Gravimetric Measurements of Particulate. Atmospheric Environment, 11, 1065-73, 1977.

12. Committee on Air Pollution: Interim Report Cmd 9011 December 1953; Report Cmd 9322 November 1954. Chairman - Sir Hugh Beaver, M.Inst.C.E., M.I.Chem.E. Her Majesty's Stationery Office, London.

13. World Health Organisation Expert Committee. Urban Air Pollution with Particular Reference to Motor Vehicles. Technical Report Series: No. 410. Geneva, 1969.

14. Department of the Environment. Calculation of Road Traffic Noise. Her Majesty's Stationery Office, London. 1975.

15. M.J. Duggan. Inorganic Lead in Ambient Air - How should its Significance be Assessed? GLC, Scientific Branch, Environmental Sciences Group Report ESG/EA/R17A, 1975.

16. M.J. Duggan and S. Williams. Lead-in-dust in City Streets. The Science of the Total Environment 7, 91-97, 1977.

17. R. Stephens. The Total Relationship between Airborne Lead and Body Lead Burdens. Proceedings of the Symposium held in London on Lead Pollution - Health Effects. p.p. 1-12, April 1978 (Organised by the Conservation Society Pollution Working Party).

18. The Toys (Safety) Regulations 1974. Statutory Instrument 1974 No. 1367. Her Majesty's Stationery Office.

19. Pencils and Graphic Instruments (Safety) Regulations 1974. Statutory Instrument 1934 No. 226. Her Majesty's Stationery Office.

20. N.A.R. Falla. Paint Research Association, Teddington. Private communication.

21. The Lead in Food Regulations 1961. Statutory Instrument 1961 No. 1931. Her Majesty's Stationery Office.

22. The Lead in Food (Amendment) Regulations, 1972. Statutory Instrument 1972, No. 1843. Her Majesty's Stationery Office.

23. Ministry of Agriculture, Fisheries and Food. Food Additives and Contaminants Committee Review of the Lead in Food Regulations 1961. FAC/REP/21.

24. Ministry of Agriculture, Fisheries and Food. Working Party on the Monitoring of Foodstuffs for Heavy Metals - Second Report. Survey of Lead in Food. Her Majesty's Stationery Office, London, 1972.

25. World Health Organisation Task Group on Environmental Health. Environmental Health Criteria 4. Oxides of Nitrogen. Geneva, 1977.

26. R.J.W. Melia, C. Du V. Florey, S.C. Darby, E.D. Palmes and B.D. Goldstein. Differences in NO_2 levels in Kitchens with Gas or Electric Cookers. Atmos. Environment. 12, 1379-81, 1978.

27. D.J. Ball and R.E. Bernard. An Analysis of Photochemical Pollution Incidents in the Greater London Area with Particular Reference to the Summer of 1976. Atmospheric Environment, 12, 1391-1401, 1978.

28. D.J. Ball and R.E. Bernard. Evidence of Photochemical Haze in the Atmosphere of Greater London. Nature, 271, 733-4, 1978.

29. National Primary and Secondary Ambient Air Quality Standards. Fed. Register 36 (84): 8186. April 30, 1971.

30. Royal Commission on Environmental Pollution. Fifth Report Air Pollution Control: An Integrated Approach. Cmnd. 6371. Her Majesty's Stationery Office, London 1976.

TABLE 1

TWO HIGHEST SMOKE AND SULPHUR DIOXIDE READINGS REPORTED IN LONDON DURING THE DECEMBER 1952 AND DECEMBER 1975 POLLUTION INCIDENTS

CONCENTRATIONS IN ug/m^3			
DATE 1952	SATURDAY 6 DECEMBER	SUNDAY/MONDAY 7/8 DECEMBER	TUESDAY 9 DECEMBER
Smoke	(4,000) (3,500)	(4,500) (2,700)	(4,000) (2,100)
SO_2	2,800 2,700	3,800 3,300	3,500 3,500
DATE 1975	MONDAY 15 DECEMBER	TUESDAY 16 DECEMBER	WEDNESDAY 17 DECEMBER
Smoke	700 500	800 700	500 400
SO_2	1,000 800	1,200 1,200	600 600

( ): It is almost certain that actual smoke levels were much higher than those reported values (see reference 4).

TABLE 2

DISTRIBUTION OF SMOKE AND SULPHUR DIOXIDE NATIONAL SURVEY MONITORING SITES IN RELATION TO THE DISTRIBUTION IN SULPHUR DIOXIDE EMISSIONS FROM SOURCES EACH EMITTING LESS THAN 30 TONNES SO_2/ ANNUM IN GREATER LONDON FOR THE YEAR 1975-6.

EMISSION DENSITY IN TONNES SO_2 PER SQ KM PER ANNUM	AREA IN SQ KM WITH GIVEN EMISSION DENSITY	NUMBER OF MONITORING SITES IN AREA	MEAN AREA PER SITE IN SQ KM
<10	625	13	48
10 - 50	663	58	11
50 - 100	189	35	5.4
100 - 250	87	18	4.8
>250	16	10	1.6

Emission density data taken from reference 10.

TABLE 3

MEDIAN SMOKE AND SULPHUR DIOXIDE LEVELS OF THE ANNUAL MEANS FOR ALL THE NATIONAL SURVEY MONITORING SITES IN LONDON FOR THE YEAR 1952/3 AND THE YEARS 1972/3 to 1976/7.

Year	52/3	72/3	73/4	74/5	75/6	76/7
Median of Annual Mean Smoke readings, $\mu g/m^3$	316	35	34	26	32	27
Median of Annual Mean SO_2 readings, $\mu g/m^3$	359	111	111	90	96	90
Number of Sites in operation	8	146	138	137	134	126
Number of Sites for which Smoke/SO_2 means have been calculated	4/6	88/87	97/93	84/83	79/75	78/78

TABLE 4

SHORT AND LONG TERM MEAN CARBON MONOXIDE CONCENTRATIONS RECORDED CLOSE TO A HEAVILY TRAFFICKED ROAD (40,000 Vehicles/24h.) IN CENTRAL LONDON DURING JANUARY TO MARCH 1979

	Carbon Monoxide Conc mg/m^3				
Period	Max.	Min.	Highest 1-hr	Highest 8-hr	Mean 24-hr
1 day (high)	58	20	35	26	13
1 day (low)	3	1	2	2	1
5 day avg	–	–	10	8	5
50 day (avg daily	–	–	13	8	6
50 day (std dev	–	–	7	5	2
50 day (f% *	–	–	Zero	34	–

* Per centum of days above GLC air quality guideline level. Sampling point about 6 m above and 10 m back from the kerbside.

TABLE 5

AIRBORNE INORGANIC LEAD LEVELS RECORDED CLOSE TO A HEAVILY TRAFFICKED ROAD (40,000 vehicles/24h) IN CENTRAL LONDON DURING OCTOBER TO MARCH 1977

AIR BORNE LEAD CONC ug/m^3				
NUMBER OF SAMPLING PERIODS	MAX RDING	MIN RDING	MEAN	STD DEV
24 weekly samples	3.7	1.1	2.0	0.6

Sampling point about 6 m above and 10 m back from kerbside.
30% of traffic diesel engined vehicles.

TABLE 6

MEASURED 1, 3 AND 6 MONTHLY MEAN CARBON MONOXIDE CONCENTRATIONS (NORMALISED) COMPARED WITH THE 24 MONTHLY MEAN CONCENTRATION

LENGTH OF MONITORING PERIOD	RELATIVE 24-MONTHLY MEAN CONC
1 month	0.7 - 1.4
3 month	0.8 - 1.3
6 month	0.85- 1.15
24 month	1.0

TABLE 8

COMPARISON OF APPARENT MEAN SMOKE LEVELS RECORDED CLOSE TO A HEAVILY TRAFFICKED ROAD (40,000 vehicles/24h, 30% diesel engined vehicles) WITH CONCENTRATIONS RECORDED AT A NEARBY BUT SHELTERED NATIONAL SURVEY SITE

MONITORING SITE *	NO. OF WEEKS	APPARENT SMOKE CONC. $ug/m^3 \pm$ s.d.	RATIO OF ROADSIDE TO NATIONAL SURVEY READINGS
Roadside	13	74 ± 21	3.1 ± 0.7
National Survey	13	26 ± 12	

* Roadside sampling point about 6m above and 10m back from kerbside. National Survey site is Lambeth 14, 200m away. (18.8.77. - 11.11.77.)

TABLE 7

RANGE OF LEAD IN DUST LEVELS MEASURED IN REAR PAVEMENT DUST SAMPLES COLLECTED ALONG EXAMPLES OF HEAVILY, MODERATELY AND LIGHTLY TRAFFICKED ROADS IN OUTER GREATER LONDON IN MARCH AND APRIL 1979

LEAD IN DUST CONC ppm									
ROAD	FLOW vh/24h	LENGTH km	NO. OF SAMPLES	MEDIAN CONC	CONC DISTRIBUTION <500	500-1000	1000-1500	1500-2000	2000
Main	40,000	4	26	900	2	13	8	2	1
Inter-mediate	15,000	1	12	1,100	0	5	3	2	2
Side (various)	<5,000	-	8	350	6	2	0	0	0

TABLE 9

SOME NITROGEN DIOXIDE LEVELS RECORDED AT NON-ROADSIDE AND ROADSIDE SITES

		NITROGEN DIOXIDE CONC.ug/m^3			
MONITORING SITE	PERIOD	NO. OF HRS 1-HR MEAN 190 μg/m^3	MEAN DAILY HIGHEST 1-HR	MEAN DAILY HIGHEST 8-HR	MEAN 24-HR
Domestic a	1 day (0000-2400)	7	850	280	150
Domestic b	8 site-days (0000-2400)	-	-	-	130
Garage c	10 days (0900-1700)	-	-	150	-
Garage c	10 days (0730-0830)	-	230	-	-
Roadside d	1 day (high) (0000-2400)	4	220	180	140
Roadside d	30 days (0000-2400)	7	110	-	70

a: Kitchen with unflued gas appliance
b: 2 Kitchens with unflued gas appliances (see reference 26)
c: Parking space for 65 petrol engined buses - measurements made in maintenance area
d: 6m above, 10m back from kerbside in central London. 40,000 veh/24h. (8.7.78 to 7.7.78)

TABLE 10

SOME OZONE LEVELS RECORDED IN GREATER LONDON

		OZONE CONC ug/m^3		
MONITORING SITE	PERIOD	NO. OF HRS 1-HR MEAN 160 μg/m^3	MEAN DAILY HIGHEST 1-HR	HIGHEST 1-HR
Teddington	22.6.76 to 8.7.76	146	270	420
County Hall	ditto	95	230	420
Hainault	ditto	135	250	360
County Hall	11.5.76 to 30.9.76	148	110	420
County Hall	1.5.75 to 30.9.75	87	87	300

(See reference 27)

TABLE 11

SOME CARBON MONOXIDE LEVELS RECORDED AT NON-ROADSIDE AND KERBSIDE SITES

		CARBON MONOXIDE CONCENTRATIONS mg/m^3				
MONITORING SITE	PERIOD	HIGHEST ½-HR	MEAN DLY HIGHEST ½-HR	MEAN DLY HIGHEST 1-HR	MEAN DLY HIGHEST 8-HR	MEAN DAILY 24-HR
Domestic a	2 days	192	168	97	32	17
Garage b	1 day	-	-	356	118	62
Car park enclosed c	1 day	-	-	509	254	122
Road tunnel whole d	10 days	>179	109	80	44	-
Road tunnel locally e	10 days	>540	292	223	128	-
Kerbside major f	29 days	-	-	17	14	9
Kerbside minor g	47 days	-	-	5	4	2

a: kitchen with unflued gas appliance
b: parking space for 65 petrol engined buses - measurements made in maintenance area
d: estimated average values along length of tunnel
e: values at foot of exhaust shaft
f: approximate traffic flow 40,000 veh/24h
g: traffic flow 5,000 veh/24h

Figure 1

Trend in Per Centum of National Survey Sites in Greater London Not Meeting W.H.O. Long Term Goals

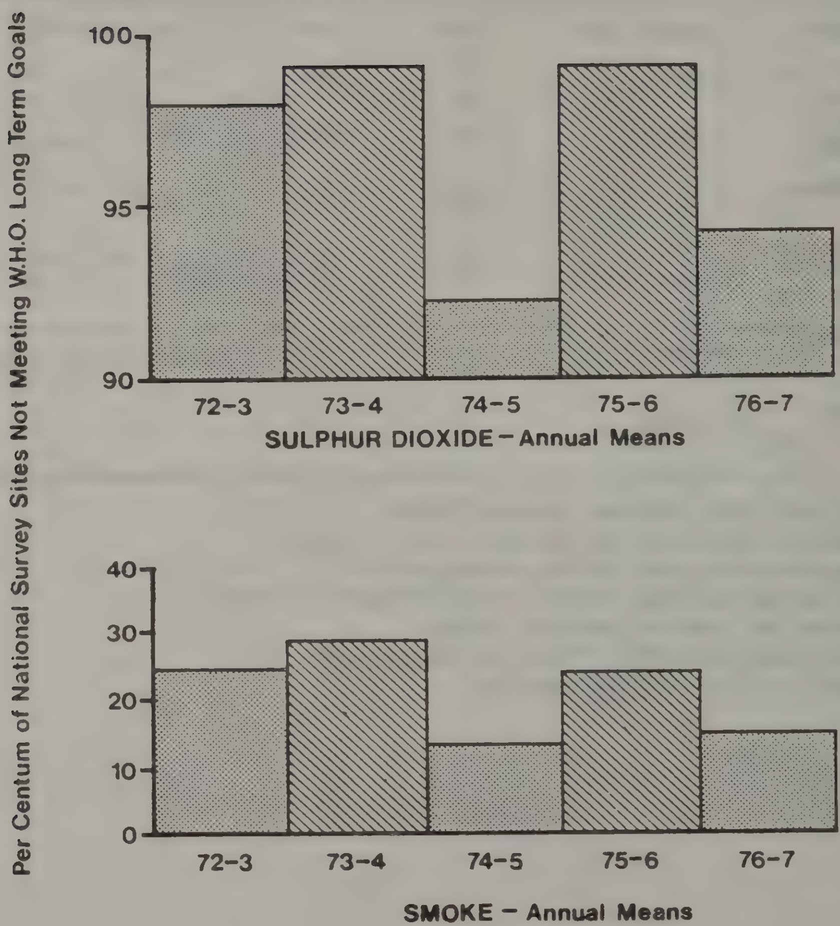


Figure 2

A GREATER LONDON ROAD TRAFFIC POLLUTION MAP

★[3 month avg. max. daily 8hr. mean CO concentration 10mg/m^3]

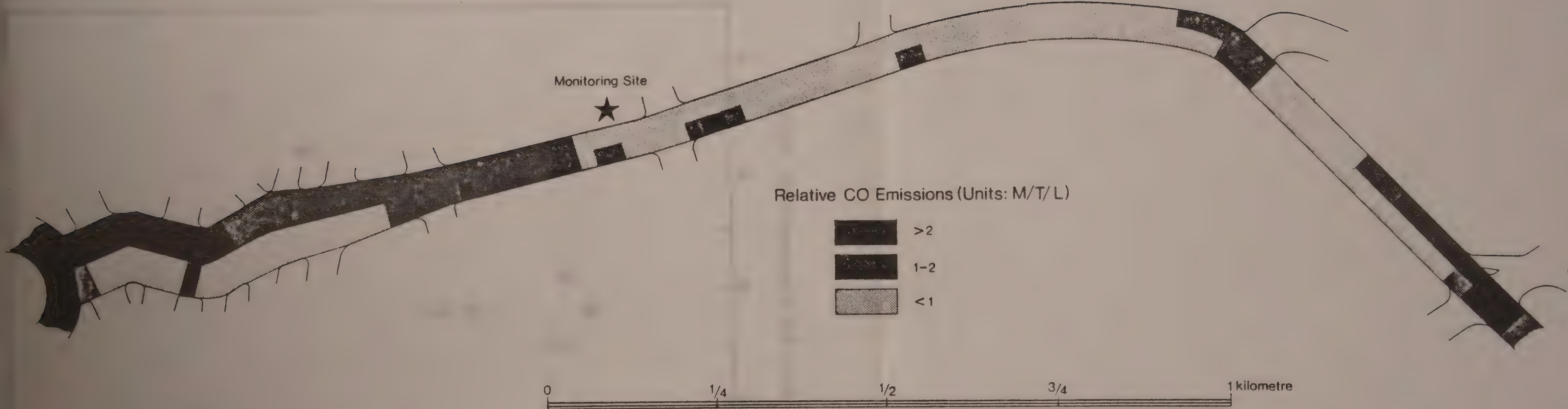


Figure 3

Three Month Mean Daily CO Concentration Against Estimated Mean Daily Traffic Density

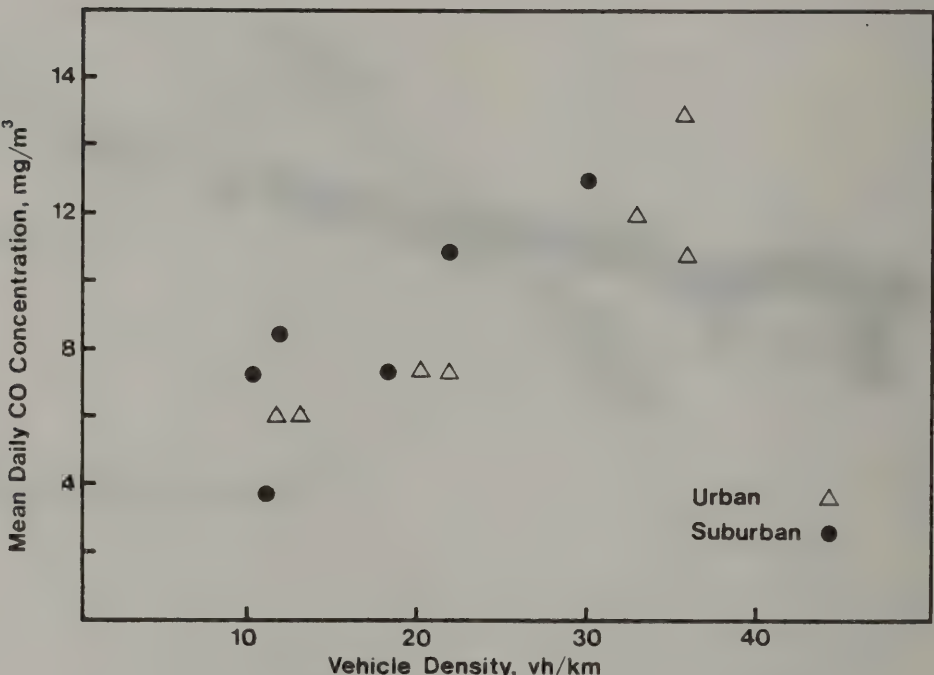
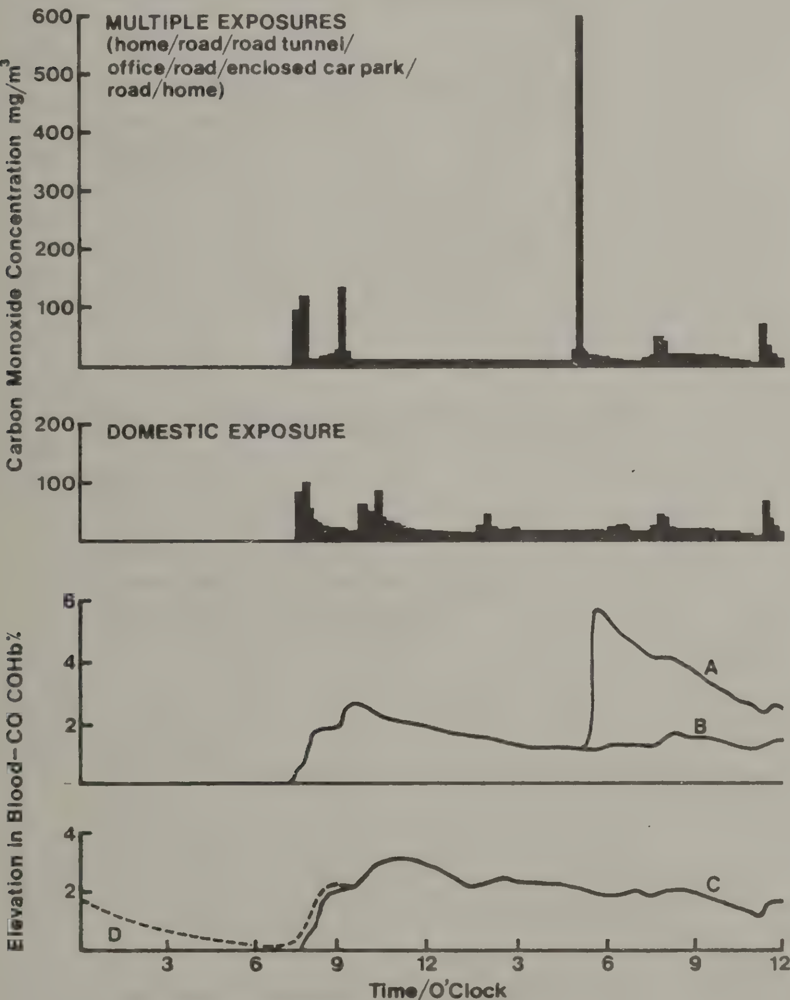


Figure 4

Calculated Elevation in Blood–CO Due to Multiple Exposures and to Domestic Exposure Alone



A: due to multiple exposures

B: " " " " less 600 mg/m³ peak

C: due to domestic exposure only

D: " " " " " , initial COHb% = 1·8%

NATIONAL SOCIETY FOR CLEAN AIR

46th ANNUAL CONFERENCE
15-18 OCTOBER 1979
SCARBOROUGH

THE EFFECTS OF POLLUTION ON CLIMATE

by

Dr. B.J. Hoskins,
Department of Meteorology,
University of Reading

National Society for Clean Air
136 North Street
Brighton BN1 1RG
England

1. INTRODUCTION: THE PAST CLIMATE OF THE EARTH

In order to gain a perspective on the possible effects of man's pollution on our climate we must consider what we mean by the word climate and how the climate of the Earth has varied in the past without our "help". We may think of climate as being made up of the statistical properties of the weather in a certain period. These statistical properties should include not only the average, though this is all that will be discussed here, but also the variations from the average. For many agricultural purposes the extremes of weather are crucial.

For most of the last 1000 million years the Earth has been ice free. However the present glacial age which may be said to have started 10 million years ago is at least the third such age in this period. In the last million years the climate has been characterised by an alternation of glacial and interglacial episodes, marked in the Northern Hemisphere by the waxing and waning of continental ice sheets and in both hemispheres by periods of rising and falling temperatures. Fig. 1a shows a reconstruction of Northern Hemisphere air temperature for the last 150,000 years based on pollen records and on worldwide sea-level records. The most recent counterpart of our present climate was about 115,000 years ago. From this peak, the temperature fell in an irregular manner to give a maximum ice extent between 22 and 14 thousand years ago. Apart from a 700 year hiccup 11 thousand years ago, the temperature rose to a maximum, rather higher than today, from 7 to 5 thousand years ago. Coming to the last thousand years, an estimate of the severity of winters in Eastern Europe is shown in Fig. 1b. There was a warm period in the Middle Ages (1150 - 1350 AD) and a cold period from 1430 - 1850 AD which is often referred to as the 'Little Ice Age'. In the twentieth century it appears that the Northern Hemisphere was at its warmest around 1940, with some cooling from then until 1970.

Thus climate has always changed and would have continued to do so in the absence of man's interference. No-one can give definite reasons for these changes though, on the longer time scale, the variation of the sun, rotation rate of the Earth, the composition of the atmosphere and the distribution of continents are probably all important. The glacial-interglacial fluctuations of the present ice-age are probably connected with certain parameters of the orbit of the Earth around the sun. However, just as the day to day weather contains a certain predictability, so the atmosphere plus ocean plus ice system might contain large variations on long time scales even in the absence of "external" causes.

As an aid to judging the possible importance of man's influence on climate, it is useful to note that the typical variation in temperature over the twentieth century is about $\frac{1}{2}$ °C, over the last thousand years (including the Little Ice Age) about $1\frac{1}{2}$ °C, and in the last million years (glacial to interglacial) about 10 °C.

2. CLIMATE MODELLING

It is always tempting, when confronted by graphs like those in Fig. 1 and when surrounded by a great demand for a climate forecast, to look for cyclic behaviour and to use these cyles to extrapolate the past to the future. However very few postulated cycles have withstood the test of modern analysis techniques and the predictive power of those that have is extremely limited. Further, the past provides no clue at all as to the possible influence of man on climate. Therefore any predictive capability depends on understanding and modelling the climate system. Such an understanding will enable us to isolate the parts of the system most susceptible to man's interference.

Climate is essentially the weather over a certain period. The weather is a description of the state of the atmosphere. The driving of the atmospheric "heat engine" is by the radiation from the sun. Fig. 2 shows what presently happens to that radiation. About 30% is reflected directly back into space by the air, clouds and the surface of the Earth. About 19% is absorbed by water vapour, clouds, dust and ozone in the atmosphere, leaving just over half the total to be absorbed by the land-ocean surface. Of this 51%, only 6% is radiated directly back into space. The rest is used to evaporate water, heat the air near the ground, or is absorbed by water vapour and carbon dioxide in the atmosphere.

Some crucial parts of the system are immediately apparent. One is the effect of carbon dioxide in the atmosphere. It should be noted that carbon dioxide was not mentioned as absorbing the incident radiation of the sun but only as absorbing the radiation from the surface. It lets the heat in but tends to stop it escaping. For obvious reasons, this is referred to as the "greenhouse effect".

Water vapour and clouds play a role in determining the heat that gets to the surface and the amount that escapes again directly. Ozone and dust are important for the solar but not the Earth radiation. Dust is also important because water vapour in the air can condense around such aerosols leading to cloud formation.

The role of the Earth's surface is absolutely crucial. The amount

of reflected solar radiation varies tremendously with the type of surface. A surface covered by snow or ice reflects most of the sun's rays. One covered by forest reflects very little. The state of the surface also determines what portion of the incident radiation is used to evaporate water.

The picture described above is an average picture. When we consider a planet covered by some ocean, some land and some snow and ice, the situation becomes much more complicated. The top few metres of ocean can store as much heat as the entire atmosphere. Ocean currents move this heat around. The bottom waters of the big ocean basins only respond to surface temperature changes on a thousand year time scale. The characteristics of the land vary according to the time of year, the previous weather and the local bio-system. The land surface also causes significant uplift to the overlying atmosphere because of the presence of mountains.

The other major effect of the underlying surface on atmospheric motion is to provide a drag. This drag again varies greatly according to the surface characteristics.

The atmosphere responds to the forcings and dampings we have mentioned, its response being dominated by the relatively fast rotation rate of the underlying planet and by the receipt of more solar radiation in equatorial than polar regions. Clearly the actual axis and rotation rate of the planet and its orbit around the sun are crucial in this respect. Even the rotation rate of our planet is not constant on the longer time scales. 1.5 thousand million years ago there were probably 800-900 days per year!

The idea of positive and negative feedbacks is one that occurs frequently in the study of climate. For example, a cold spell might be expected to lead to more snow and ice. This would tend to reflect more of the sun's radiation and thus enhance the cold regime. In this way such positive feedback processes may amplify an initially small departure from normal. Clearly negative feedback processes also exist, otherwise our climate would have been extremely unstable in the past.

Much effort has been expended in the last few years in producing and studying mathematical models of the Earth's climate. At the simplest end of the scale there are models that deal with the atmosphere averaged in all three space dimensions as well as in time and include very simple representations of all the physical processes mentioned above. At the other end of the spectrum, there are models which try to predict the details of the weather for each

day and which include sometimes quite sophisticated representations of physical processes. These models have to be used to simulate enough days to obtain a model climate.

The simple models have the advantage that one can hope to understand how the model climate is produced. They run fast enough on the computer for one to perform climate change experiments. The complicated models are not easy to diagnose and are extremely expensive in computer time. However, the fact that they do not contain as many simplifications may be crucial in representing climate, particularly as one might wish to know the climate in the U.K., and not an average between 50° - 60°N all the way around the Earth.

All the different sorts of model are useful for indicating the possible effects on climate of certain changes, but at this point none of them can be thought of as being reliable. For example, a good representation of the ocean is vital. Our present understanding is just insufficient for this to be done. The complicated models are developments from weather forecast models. We all know that even one-day forecasts can sometimes be in great error. This does not give confidence in their behaviour on longer time scales. As far as I know no-one has been able to predict with hindsight the extreme cold of the American winters of 1976-77 and 1977-78. Equally, the reasons for the hot, dry summer of 1976 here in the U.K. are not known. Such anomalies, if they persisted or even if they occurred more frequently, would be a climatic change of significant proportions.

The Global Atmospheric Research Program which is sponsored by the International Council of Scientific Unions and the World Meteorological Organization has mounted a Global Experiment to obtain good observations over the period of a year to aid in the understanding of the atmosphere and in the development and validation of climate models. A World Climate Program is being initiated and much progress can be expected in the next decade, but again I stress that our present knowledge is insufficient to produce reliable climate forecasts and that this must be borne in mind when anyone indicates the possible effects of man's activities.

As a final comment on modelling, I would like to emphasise how global and sophisticated must be our view when considering climate. Fig. 3 shows the low-level temperature response of a simple model atmosphere to a steady heating between 10 °N and 20 °N in the hatched area indicated. The change is not local and is not all of the same sign. In fact the largest temperature anomaly is a <u>cooling</u> north of 70 °N and some 90 ° of longitude downstream.

3. MAN'S INFLUENCE ON CLIMATE

There are two parts to the assessment of the future impact of man's pollution on climate. The first is a prediction of man's activities and the second a prediction of the effects of these on climate. Those activities which are important for this question are either those which will significantly alter one of the major components of the climate system or those which will act as catalysts because of the positive feedbacks in the system. Determination of the latter is much more difficult than the former and probably impossible at present.

One of the major components of the climate system which we know has been altered is the amount of carbon dioxide in the atmosphere. Because of the burning of fossil fuels it is estimated that the nineteenth century content of 290 parts per million (ppm) has risen to 330 ppm. Only about half the carbon dioxide produced has remained in the atmosphere. The rest has been absorbed by the ocean or by living matter. It would take a foolhardy person to predict the future burning of fossil fuels. Even if this were known, we do not understand how much would remain in the atmosphere. Extrapolating from the past decade would suggest a doubling of atmosphere carbon dioxide by the middle of the next century. We have already discussed carbon dioxide and the "greenhouse effect" and so it is clearly seen that extrapolation of past activity suggests a significant tinkering with the climate system well within a century. Climate models of all shapes and sizes have been used to study this problem. They suggest that surface air temperatures might increase by 1.5° - $3.0^{\circ}C$ on average. This does not imply this sort of rise everywhere. Some areas might even be cooler, but in polar regions rises of the order of $10^{\circ}C$ are predicted.

If these estimates are in any way reliable, a doubling of atmospheric carbon dioxide would produce changes at least comparable with those between the Little Ice Age and the present. The generally higher temperatures would almost inevitably lead to more vigorous hydrologic cycle including more precipitation with a different distribution from that presently observed. Again, some places would have less precipitation than at present.

Another possibly important product of our demand for energy is the waste heat produced. The average amount of solar radiation reaching the Earth's surface is 170 W m^{-2}. The present world consumption of energy averages at about 1/60 W m^{-2}. With any foreseeable rise in energy usage, the average input of heat in this manner must remain negligible. Thus the only importance could be as a

local heat input which might produce a local effect and consequent impacts elsewhere. The heat input from Manhattan is estimated to be about 90 $W\ m^{-2}$. If this magnitude of thermal pollution was emitted over a significant region then we might expect a climatic response. Indeed, a computer model suggested (4) that such a megalopolis covering the entire eastern USA would produce a local winter warming of 12°C and summer warming of 3°C. The response elsewhere was doubtful. A model developed by the U.K. Meteorological Office has been used to study the possible effects of a huge energy complex which would be situated at sea to facilitate cooling (5). When the local thermal pollution was 20 times the total present world consumption there were significant local and nonlocal effects.

Before considering pollution from other activities of man, it is worth noting that projected "clean" forms of energy production might have impact on the climate. Large-scale use of solar power would mean that the solar heating would be released at the place of energy use, thus changing the heating distribution. Possible use of the vertical temperature gradient in the ocean to generate electricity might result in anomalous sea-surface temperatures and consequent changes in climate.

Gases other than carbon dioxide also contribute to the "greenhouse effect". Nitrogen compounds are released through the use of fertilisers and also fossil fuels. Again present behaviour would suggest doubling of nitrous oxide during the next century. Estimates of the effect of doubling nitrogen compounds suggest a heating of about $\frac{1}{4}$ of that due to doubling carbon dioxide. Chlorofluromethanes (CFM's) which are used as refrigerants and as propellants in aerosol cans also stop the radiation from the Earth escaping. It has been suggested that they could increase surface temperature by $\frac{1}{2}$ °C on average.

Anotner important effect of increased nitrous oxide and the CFM's is that they are expected to reduce the ozone in the stratosphere by a significant proportion. This would result in increased harmful ultra-violet radiation reaching the surface. From the point of view of the climate, the smaller amount of ozone would result in less heating high in the atmosphere. The consequent effects, if any, near the surface are not known.

The net effect of all the dust particles that man produces is also unknown. In some areas they probably increase the amount of solar radiation reflected: in others they probably decrease it. They probably lead to increased cloud though not necessarily increased precipitation.

Referring back to the brief description of the climate system in Section 2, one portion which we have not yet considered is the effect of man on the properties of the surface of the Earth. When forest is turned into agricultural land the amount of solar radiation reflected back to space is increased, the evaporation of water is decreased, and so is the drag of the surface on the atmosphere. The net effect on surface temperature is almost certainly to give a cooling. It has also been argued (6) that overgrazing in marginal desert regions increases the reflectivity of the surface, and that the atmospheric response is to produce decreased precipitation, therefore enchancing the arid conditions.

4. CONCLUSION

The climate of the Earth has always been changing and in the absence of man's interference would have continued to change. On the time scale of tens of thousands of years it is probable that our climate would have become colder. The time-scale of man's activities suggests that over the next century the effect of his pollution on climate could be dominant over any natural variation. Our understanding of the atmosphere, oceans and ice is such that no definitive predictions can be given. This is particularly true when we consider the crucial variations of the climatic effects from one place to another.

The evidence that we have suggests that most of man's pollution is leading towards a warming. The effect of the carbon dioxide produced from the burning of fossil fuels is thought to be most important in this respect. Extrapolating from energy trends in the last decade, the best present knowledge suggests that by the middle of the next century man's activities would have led to a change in climate including an average 2°C temperature rise. This would make the Earth almost as warm as 115,000 years ago and probably as at any time in the last million years. The precipitation amounts would change and those areas suitable for growing specific crops would be different.

Although our knowledge is insufficient to predict with any accuracy, it can already been stated that taking account of possible affects on climate must be part of any energy strategy. This must be a global strategy - climate knows no national bounderies.

REFERENCES

The author has gathered much information from two books:

1. Understanding climate change. U.S. National Academy of Sciences, 1975.

2. Man's impact on climate. Developments in Atmospheric Science, 10. W. Bach, J. Pankrath, W. Kellogg, eds. (Elsevier, 1979).

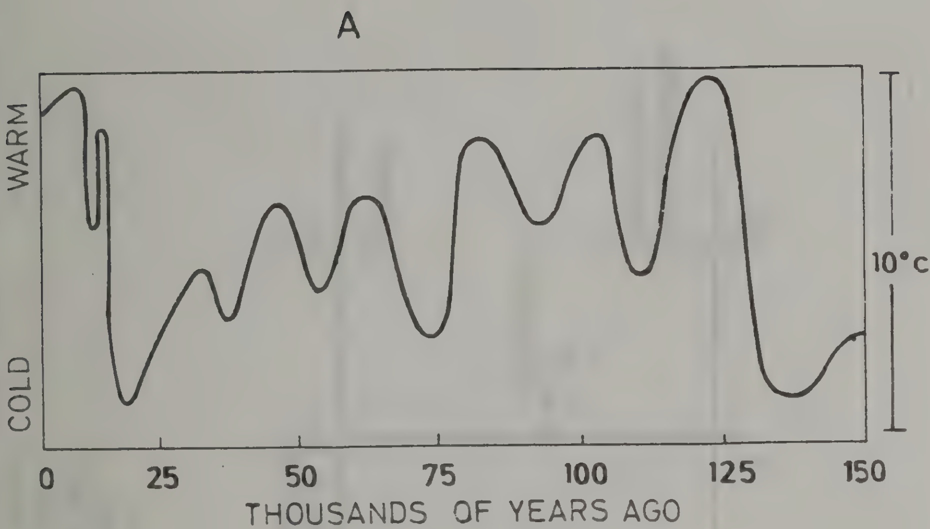
Other references:

3. Lamb, H.H. World survey of climatology, 2, General Climatology, H. Flohn, ed. (Elsevier, pp 173-249, 1969).

4. Washington, W.M. and Chervin, R.M. J. App. Met, 18, 3-16 (1979).

5. Williams, J., Kromer, G. and Gilchrist, A. IIASA Research Memorandum RM-77-15, 2361, Laxenburg, Austria (1977).

6. Charney, J.G. Quart. J. Roy. Met. Soc., 101, 193-202 (1975).



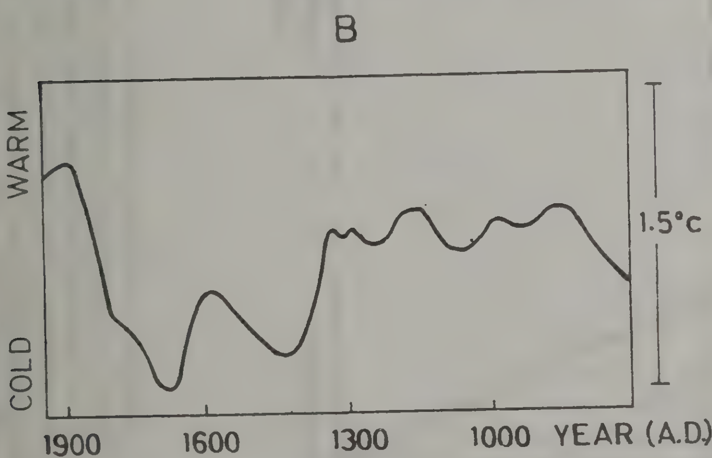
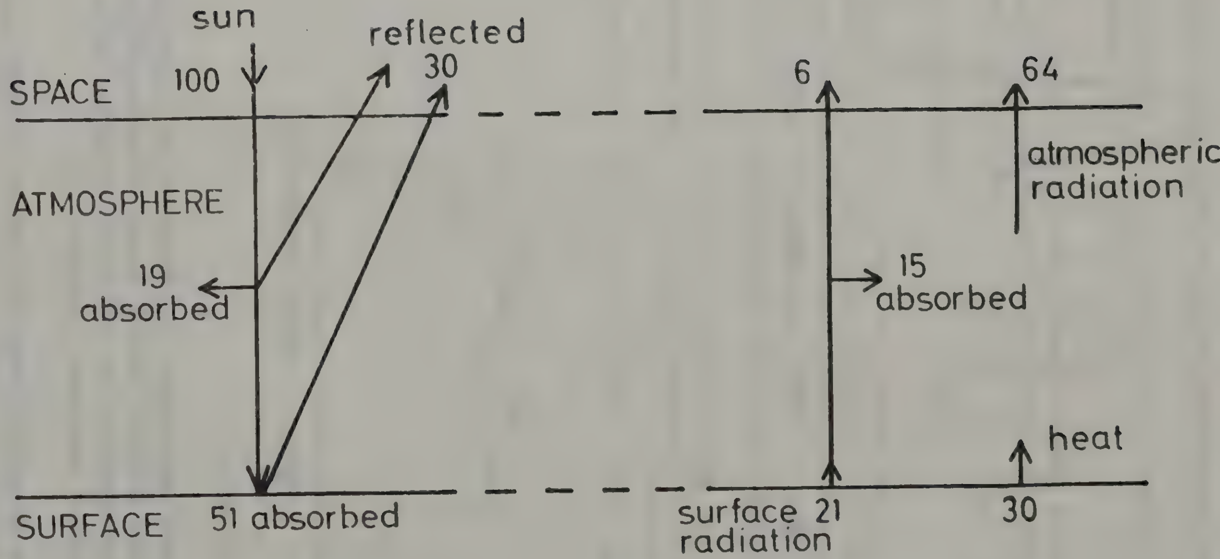


Fig.1 The past climate.

A. Northern Hemisphere air-temperature trends during the last 150,000 years, based on mid-latitude sea surface temperature and pollen records and on world-wide sea-level records. (1)

B. Winter severity index for eastern Europe during the last 1000 years. (3)

In both graphs the present time is at the left-hand side.



<u>Fig.2</u> The mean annual radiation and heat balance of the atmosphere, relative to 100 units of incoming solar radiation. The left-hand portion shows how only 51% is absorbed by the surface. The right-hand portion shows how the absorbed radiation is returned to space.

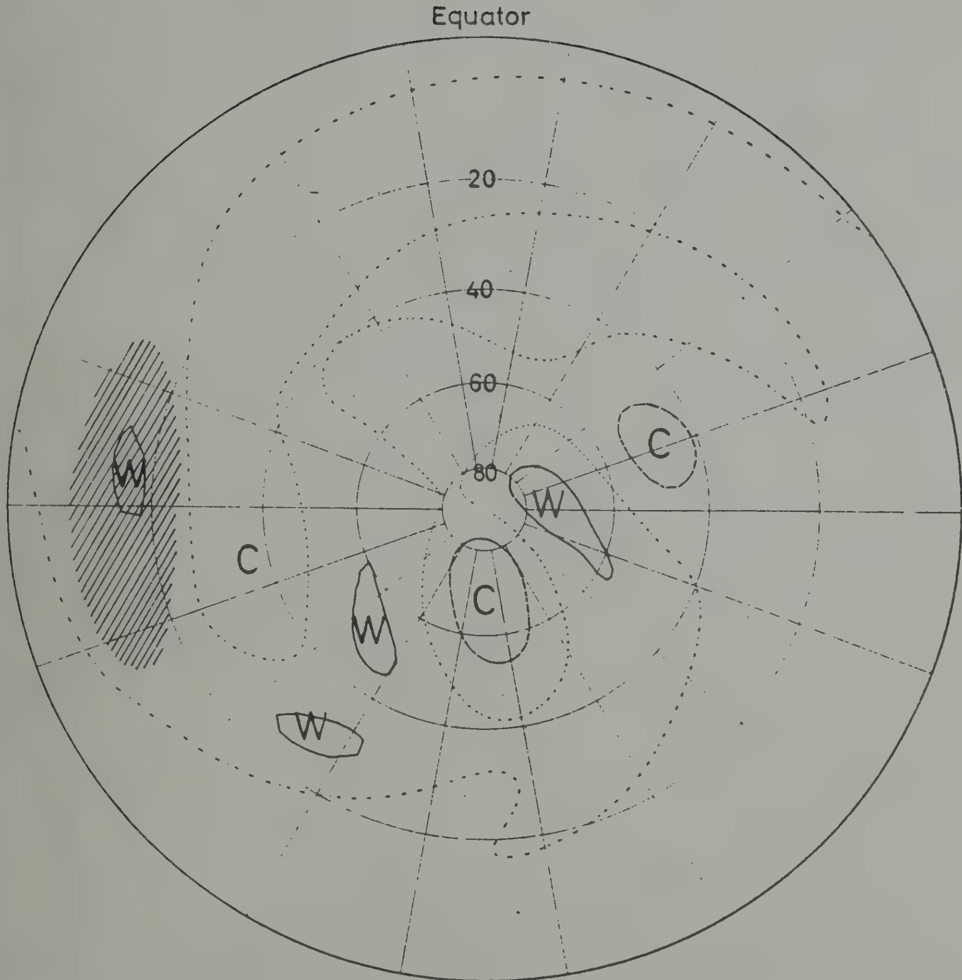


Fig.3 The steady state temperature perturbation at low levels forced by anomalous heating in the hatched area. The model used for this prediction deliberately omits many of the complexities of the climate system. The area shown is the northern hemisphere. Lines of latitude and longitude are drawn every 20°. C and W indicate cold and warm areas respectively. The dashed conour is the zero line.

NATIONAL SOCIETY FOR CLEAN AIR

46TH ANNUAL CONFERENCE
15-18 OCTOBER 1979
SCARBOROUGH

WEATHER AND AIR POLLUTION

PART 2
DISCUSSIONS

136 NORTH STREET
BRIGHTON BN1 1RG ENGLAND

46th ANNUAL CONFERENCE
SCARBOROUGH, 15th - 18th October 1979

NATIONAL SOCIETY FOR CLEAN AIR

46th ANNUAL CONFERENCE
15-18 OCTOBER 1979
SCARBOROUGH

THE WEATHER

by

Jack Scott
Meteorological Office

National Society for Clean Air
136 North Street
Brighton BN1 1RG
England

Although the National Society for Clean Air may not always have been interested in the weather, mankind has been interested throughout history in the weather and how it is formed. Aristotle, writing about the weather, coined the word 'meteorology' in the 4th century before Christ, and in the Bible, Matthew 16, verses 1, 2 and 3 talk of the 'red sky at night'.

But it is really only in the last 150 years or so that scientists have got to grips with the weather. In the 17th or 18th century, when Torricelli and his barometer came along together with all the various instruments produced in that period, people took a great interest in the weather, but a real scientific understanding was only begun in the middle of the last century.

The advent of the aeroplane opened up the possibilities for a deeper study of the weather. The weather is the atmosphere in motion, or in action, specifically the bottom 5 or 10 miles of the atmosphere. Higher in the atmosphere, the air becomes rarer and does not have a great effect on what happens near the ground, although in the past twenty years there has been increasing interest in the stratosphere, and it is now widely believed that the stratosphere affects the weather to some extent. But it is the bottom 5 or 10 miles that meteorologists are most concerned with, so it was not until some means of measuring what goes on in these 5 or 10 miles was found that a proper understanding of the weather was possible. Before the aeroplane, in the days of the first hot air balloons, meteorologists went up with instruments, trying to measure what was going on up there, and sometimes actually passed out in the process, so ardent were they in the pursuit of knowledge.

Even in looking at the bottom layer, the area of study is vast. The equator is 25,000 miles around,and from pole to pole the circumference of the earth is a little less than 25,000 miles; multiplying this by the 5 or 10 miles in height, it can be seen that the cubic capacity of the area is really and truly vast, and all that volume has to be examined in order to arrive at an accurate forecast. The area can be divided into the two hemisphere ; the weather in one hemisphere doesn't have a great effect on the other hemisphere, but it is a fact that if somebody coughs in Russia it winds up doing something to the weather in Scarborough.

There are often references in the popular press about sunspots affecting the weather, all based on the fact that it is the energy that comes out of the sun that starts it all off, and

keeps the weather system going. One of the first things most of us learn at school about the weather, is that the air is heated at the equator and it rises and passes out towards the poles, lowers and then comes back. This was originally discovered in the 18th Century by a Britisher named Hadley, and so this major circulatory mechanism is called in the text books the 'Hadley Cell'. This circulation out from the equator and back again is about the only thing that most people ever learned at school, and the strange thing about it is that currently it is probably one of the processes that meteorologists know least about in detail because of the vastness of the whole process. Now meteorologists are starting to get to grips with that particular problem, which is one that needs to be solved because it is the starting point for weather, and all the energy comes from this original circulation.

In the early days, few measurements were taken over all the oceans in the world, and in what is now known as the third world; and very few observations were ever taken of what was happening higher in the atmosphere than ground level. If you cannot take account of what is happening in any particular place, it is impossible to estimate what will arrive at another place, so the total problem of the general circulation as we know it was impossible to attack until, for example, there were satellites to take the measurements over the whole globe rather than relying on samples taken from here and there. The arrival of computers has also been very significant, since once the information about current weather has been obtained, they are able to perform the necessary calculations in a very short space of time. The calculations that are necessary have been known for a long time, because they are the normal laws of physics applied to the air in movement.

What is definitely known about the general circulation of course is that it causes the movement of air. Most of the heat energy from the sun comes in near the equator; the air there rises because it becomes warmer and therefore less dense, and as it rises through the denser air sitting above it, it leaves a hole so to speak, down below. To fill that hole some air comes in from the side and the air going up at the top moves out, and so the circulation is formed. The Hadley Cell is basically just like the domestic hot water system, with a boiler, boiling water which goes up a pipe and around a circulation and eventually there is colder water coming in at the bottom of the boiler and this is exactly what the air is doing, being heated at the equator, going aloft, coming down and coming in again, moving from some

point outside the equator back towards the equator. This is wind, because wind is just air on the move. If we did not have this movement of air, if we did not have air aloft moving away from the equator carrying heat, and the movement back to the equator of colder air, at a lower level the earth would slowly get hotter and hotter at the equator and colder and colder at the poles until life as we know it at the moment would not exist. So we depend on weather to exist and the wind is a very important feature of the weather,keeping the temperature of the globe fairly steady and allowing the climate as we know it today to persist. Wind keeps everything in a fairly steady state.

But the state of the weather is not absolutely steady. It will rain one day, but not the next, because of those well known areas of high pressure and areas of low pressure. It is still the general circulation described earlier that causes high and low pressure areas. When the air rises, it causes the pressure below to be lower than was before. When it goes out towards the poles and starts to sink it is pushing down on the air below it as it sinks and the pressure there becomes higher. In areas of high pressure, there is very little movement, as the air is settling. The television charts show these vast areas of high pressure, where there is very little wind. The air stays stagnant for some time, and it takes on the properties of the areas that it is in. If it is an Azores anticyclone, for example, over an ocean, the air becomes warm and moist. In another part of the globe in an anticyclone, over Siberia, there might be air that is cold and dry. There are many different types of air, and it is this difference that makes weather. For example, the air going from the Azores anticyclone on the surface and being carried away by the winds on the periphery of the anticyclone, eventually turns up the seaboard of the United States and may meet air coming from the north from over Canada. As the two meet side by side the warmer air, being lighter, climbs over the colder air and you get the beginning of those seemingly mysterious things shown on weather charts, called Fronts: simply warm air rising above cold air.

Another point is that air almost invariably contains a lot of water, in invisible, vapour form. And an important feature of the air is that the amount of water that it will hold as vapour depends upon the temperature of that air. If the temperature is raised, it will hold more water as vapour. If the temperature of the air is lowered, the water vapour becomes more and more crowded, so to speak, within the air and eventually has to come out as water droplets,-condensed out. So, when the

warm moist air from the Azores rises over the cold air from Canada in a Front the air rises and becomes colder and colder (because of the other physical property, that as air gets higher within the atmosphere, it gets colder because the air is expanding). As it becomes colder, the moisture within the air eventually is no longer able to be held as vapour and comes out as water droplets and clouds are formed. The growth from normal cloud droplets to rain is a physical process in itself, going on within the cloud. The cloud is made up of very tiny water droplets and in some cases if the cloud is thick enough, the top of the cloud is formed of ice crystals rather than water, and the ice crystals grow and the water droplets themselves coagulate as they collide with each other, growing one way or another until they become too heavy to stay suspended in the air because of the force of gravity, when they fall out of the clouds as rain. This is a process of forming clouds, and the process of forming rain, and it all begins in the heating-up process out at the equator.

The heating process does not come direct from the sun; the heat coming from the sun is in radiation form, which does not heat the air directly, but heats the ground and sea, which act like a domestic space heater. A space heater is heated during the day and all night long this heat comes out and warms the house. A certain amount of the heat from the sun is absorbed before it reaches earth, (a great deal of it by pollution) but once it gets down to earth, the heat is stored and then released by the sea or land masses. This explains the diurnal temperature variations: during the day the land or sea is radiating heat and being topped up all the while by energy from the sun. Once the sun goes down, the land or sea continues to radiate to heat the layer of air that is next to it, but it is not taking any incoming energy from the sun, so the land and sea cool down and eventually the layer of air above cools down, and so it gets cold at night.

Inversion of temperature is very important to specialists in air pollution, and this occurs usually in an anticyclone; inversions usually happen at night and are very often dissipated during the day. An inversion occurs when the temperature does not fall off from the ground upwards, but gets higher from the ground upwards. The point aloft where the temperature stops rising and starts to fall is the top of the inversion, and underneath that, is usually where pollution builds up. The reason for the formation of the inversion is that the ground below is cooling off, and so the air next to the ground is cooling

off; this layer of air gets colder and colder and the layers above do not change in temperature, so there is a gradual rise of temperature upwards to the top of the inversion. This happens almost invariably within an anticyclone because in an anticyclone there is little wind so the air, being still, is able to cool and the air above it has no effect on it. If there is a lot of wind, especially going over rough ground, this causes the air to mix; the air is turbulent so that the temperature at one level is interchanged with the temperature at another, the evening-out effect stopping an inversion from forming.

The forecasting of weather is not always done on the basis of the first principles discussed above. These principles are known, and the basis of forecasting is the international exchange of information throughout the northern hemisphere, to obtain the picture of the weather as it stands at the moment. In this way, it is known where it is raining, where it is fine, what the pressure is in every place, and so the forecaster can draw the weather maps which are shown regularly on television and find out what the general disposition of pressure is, and starting from there, can draw another map in six hours' time, and one after that, and one after that, and eventually obtain a set of charts, which, like flicker cards, can be flipped through, to show the patterns changing. It is a very simple process after that to guess what the next one looks like even before the map is available because they change in a flowing pattern, and with the aid of computers, the patterns for up to seven days ahead can be predicted; work is going on to extend this period. It is an international business, probably more international than any other, because meteorologists all realise that if they did not know what was happening in Russia for instance, at the moment, their own weather forecast would not be any good, and vice versa, so there is an absolutely complete exchange of information. The references of the papers presented at the conference show this international aspect; the papers are not based solely on the findings of people in the UK.

Attempts to improve weather forecasts are all based upon the modern methods that are coming up in conjunction with the use of satellites. Satellites, as well as taking their pictures, are being taught to do soundings through the atmosphere. This has hitherto been done in a few places by sending balloons up carrying sounding equipment but the satellites are now able to plumb the atmosphere from the top, in a very coarse pattern at the moment, but one which will no doubt improve. And bigger and better computers are now able to process the additional information

to make improved forecasts. The problems with weather forecasting and the inconsistency of weather forecasting in the past were mostly associated with the non-information areas like the vast oceans of the world, or the third world, but now that we are getting more and more and more information in from there, there is bound to be an improvement in weather forecasting, but not tomorrow. It is important to stress that nothing will happen overnight; research into weather forecasting is a growing business, one person building on someone else's knowledge and it is a fairly slow process.

Finally, as well as these vast areas of weather, there is small-scale weather or local weather; for instance, the sea breeze is something that happens just along the coast, the few miles inland from the coast, and a few miles out to sea. These local areas have to be taken into consideration as well. They have an effect on any particular area as far as pollution is concerned and both large and small scale weather go together to make a weather forecast.

I want to leave you with the plea that you accept the weather and how we look at the weather as a very simple thing; I have tried to present it simply and the processes are absolutely simple. It is all really common sense. It is a matter of applying the first things that you learn at school, about hot air rising or hot water rising, (because the air is really a fluid like water) and if you can think of it in simple terms you won't be baffled by anything during the conference. What looks like a deep process on paper is often just figures put to something that to everybody is absolutely common sense.

NATIONAL SOCIETY FOR CLEAN AIR

46th ANNUAL CONFERENCE
15-18 OCTOBER 1979
SCARBOROUGH

THE ACCURACY OF FORECASTING POLLUTION

by

Dr. F.B. Smith,
Meteorological Office

National Society for Clean Air
136 North Street
Brighton BN1 1RG
England

Airborne pollutants are worthy of study because of their effects on health, amenity, buildings, animals or vegetation. Sometimes it is the concentration in the air that is important, and how this concentration varies in time. In other cases it is the actual amount of the pollutant which gets deposited per unit surface area of the underlying ground by one means or another. With some pollutants both are important.

In every case the nature of the atmosphere and its ability to carry the pollutant, to dilute it and disperse it, is of vital concern.

To take an example, domestic central heating systems may emit sulphur dioxide, one of the commonest of all air pollutants. The householders will adjust the system to maintain a comfortable temperature inside the home against heat losses caused by conduction and ventilation losses. The rate of emission will therefore probably depend on the exterior wind speed and air temperature.

The 'plume' coming out of the chimney or vent will be warm and will rise. In light winds the rise may be many metres. In stronger gusty winds, the plume will get bent over quickly and may get caught up in the turbulent eddies in the lee of the house and brought down to ground very rapidly. In partial compensation the mission is injected into a longer run of wind in strong winds than in light winds, tending towards overall lower concentrations.

The sulphur dioxide is carried away downwind and the areas affected clearly depend principally on wind direction. At very short range wind direction may be treated as spatially constant. At somewhat longer range allowance might have to be made of the effect on the airflow of such things as the urban heat-island, hills and valleys. Coastal effects (e.g. sea breezes) and large clouds which generate their own meso-scale circulations.

Some of the sulphur dioxide will be absorbed by the ground and the vegetation. Some of the remainder will be oxidised to sulphate and the rate at which this occurs depends principally on the relative humidity of the air, although other meteorological factors may be important. Sulphate is absorbed by the surface much more slowly and can often travel through the atmosphere many hundreds of kilometres. Much of the sulphate is only removed when it is drawn intc a rain area and washed out, perhaps at great distances from its original source.

One can see from this briefly considered example, the daunting range of meteorological and environmental parameters that may be

important.

Except in very complex cases, the ground-level concentration of a pollutant sampled in the plume over a few minutes and at downwind distances of up to a few kilometres can usually be estimated to within a factor of about 2, compared with actual measured values, provided the emission rate is known. The accuracy improves as the period over which the plume is sampled is increased. The cause of these errors is not principally due to the inadequacies of the models we use, although of course these play some part, but is largely due to the inherent variability within an otherwise uniform air flow. At large distances downwind the accuracy becomes gradually less. The reason for this is that errors in trajectories are typically cumulative, especially on the scale of weather systems, like depressions and anticyclones.

In certain rather important instances it may be essential, or maybe just simply desirable, to forecast concentration levels ahead of time. The following examples illustrate this point. The first example refers to certain cities round the world where concentration levels of smoke and sulphur dioxide occasionally reach such levels as to present a definite hazard to inhabitants with chest and heart complaints. A concentration forecasting scheme then becomes highly desirable in order to advise the public of forthcoming levels, to provide a basis for possible emission control and to prepare hospitals for possible influxes of patients.

The second example refers to the accidental release of some toxic, explosive or radioactive material from an industrial plant. Often the release is not instantaneous but is spread over many hours. During this time the wind field (and other meteorological parameters) may change very significantly. In order to dispose whatever emergency services are available to the best possible advantage of the public, some estimate of these changes is required as soon as possible after the accident is appreciated.

The third example concerns the long range transport of industrial air pollutants and the depositions experienced in sensitive areas, maybe one or more thousand kilometres from the source regions. The deterioration in the fauna-supporting quality of many Scandinavian lakes is an example of this situation. Acid rain appears to be a major contributing factor to the decline in lake pH values and a consequential decline in the fish populations there. In theory it would be possible to alleviate this problem by forecasting air movements to Scandinavia two or three days in advance and applying fuel switching to more expensive low-sulphur fuels at appropriate

large industrial plants where this would be feasible. In practice this is a costly solution and in any case such forecasting is obviously subject to error.

The object of this paper is to look at some of these forecasting situations and to attempt to assess the accuracy with which the relevant meteorological parameters can be forecast and the consequences this has on the accuracy of concentration predictions.

Let us briefly summarise the situation here. Detailed figures will be given in the full paper.

1. URBAN POLLUTION

The Meteorological Office sulphur dioxide forecasting model for London has been in operation during the winter months since 1971, and provides a useful guide to trends in concentration. Twenty four hour average concentrations are forecast each day for the following day. Correlations between predicted and actual concentrations are typically about 0.7 to 0.75. The errors in forecasting the meteorological parameters, although relatively small, nevertheless are one of the principal sources of error in the model. Two of these parameters are the expected minimum temperature (root mean square (r.m.s.) error 2°C) and the number of hours when the mean wind falls below 5 knots (r.m.s. error 4 hours). In combination these result in a r.m.s. error of concentration of about 50 $\mu g\ m^{-3}$ (compared with a winter mean SO_2 concentration of about 200 $\mu g\ m^{-3}$).

Wind direction is relatively unimportant in most cities unless one or two very strong sources dominate the concentration pattern.

2. ACCIDENTAL RELEASES OF HAZARDOUS POLLUTANTS

The principal error here arised from changes in wind direction. An analysis of time sequencies of trajectories over a range 1 to 30 km will be presented based on hourly surface wind observations. These variations will be compared with corresponding changes in geostrophic wind direction deduced from the normal synoptic network of observing stations.

Other errors arise from variations in atmospheric stability, especially in the lower layers, and in wind speed. More serious accidents might potentially affect areas out to some 1000 km or more. A study of "trajectory swinging" in time out

to these ranges will be presented, and the results will include the effects of release period on the magnitude of the swinging.

3. EMISSION CONTROL IN THE LONG RANGE TRANSPORT OF POLLUTION PROBLEM

An analysis will be described of comparative trajectories based on forecast and actual meteorological charts over distances of the order of 1000 km (roughly the distance from London to southern Norway). It shows that the root-mean-square error at this range is of the order of 250 km which is roughly the width of Norway as viewed from southern England. Consequently fuel changing based on such forecasts could result in many failures, either misses when a hit was forecast, or vice versa. The quality of forecasting several days ahead is nevertheless improving and it may ultimately become more feasible than it is at present.

4. STABILITY OF THE ATMOSPHERE AND DISPERSION

Vertical diffusion of pollutants up or down through the atmosphere is caused by turbulent eddies embedded in the mean airflow. The more intense these eddies are, and the larger they are, the more rapid is the dispersion. If we have rapid dispersion then for sources that are some height above the ground, the concentration of whatever is being emitted is at first enhanced at the ground but is later diminished. For ground level sources, the surface concentrations are always reduced by rapid vertical dispersion.

There are two sources of energy for these turbulent eddies. As Figure 1 shows the first arises from the braking action of a rough underlying surface on the airflow. Energy is transferred from the mean motion to the eddies. These eddies in turn help to bring down mean-motion momentum from aloft to balance the losses in the surface layers. The intensity of turbulence increases both with wind speed and with roughness of the underlying surface. The typical vertical eddy velocity is about one-eighth of the wind speed measured at 10 metres over normal countryside.

The second major source (or sink) of turbulent energy is the buoyancy generated by internal density or temperature differences. These differences arise from the air and the underlying ground surface having different temperatures and water vapour pressures. Over land we can usually ignore the latter and think only of the consequential flux of sensible heat either from the ground into the air (when the ground is hotter than the air as it often is in the

day) or the reverse (as often happens at night).

As shown in Figure 2, incoming solar radiation during the day tends to heat the ground and some fraction of this may enter the overlying air as sensible heat. The elevation of the sun, the amount and type of cloud and the dampness and character of the ground surface are obvious factors determining the upward heat flux. At night the ground usually cools as outgoing long-wave radiation exceeds incoming radiation originating mainly from any clouds present.

When the sensible heat flux is upwards (from the ground to the air) the air temperature tends to increase rapidly downwards, and in consequence any fluid element perturbed upwards, say, soon finds itself hotter than its environment and gravity accelerates it upwards. The motion is unstable, turbulent notions tend to be intense and chimney plumes disperse rapidly and are sometimes fragmented (see Figure 3). At night when the heat flux is downwards, the temperature decreases downwards and perturbed fluid elements are soon restored back to their original levels. Turbulence may be entirely quenched in time, especially in clear sky conditions when surface cooling is rapid and in light winds when the dynamic generation is small.

In 1959 Pasquill, recognising these physical principles, tried to relate what experimental data on vertical dispersion was available at that time to meteorological factors related to these basic parameters. It was clearly sensible to select factors which could be rapidly observed or assessed without sophisticated instrumentation. The scheme developed was in this sense based soundly on good physical and practical concepts, but the details of the relationships were empirical. Only now are the forms of these relationships being verified by theoretical arguments. Pasquill defined six stability categories, A to F, in which A represents the most unstable conditions, B and C less unstable, D neutral, E and F stable conditions. Later a very stable category G was added to the list. Smith's modified form of Pasquill's scheme for the unstable categories is shown in Figure 4. The sensible heat flux can be estimated roughly by a variety of methods. Figure 5 shows typical values. A somewhat better method is to deduce the current elevation of the sun and, allowing for the amount of cloud, deduce the net incoming solar radiation R. An estimate of the sensible heat flux H can then be found by using the equation.

$$H = 0.4 (R - 100)$$

where H and R are in watts per square metre. Full

details of this method are given in Pasquill's famous book "Atmospheric Diffusion" (2nd Edition). Even better practical methods are available but would take too long to describe here.

Knowledge of the Pasquill stability P, the wind speed u and the roughness of the ground enable unique estimates of plume depth to be determined as a function of distance downwind from the source. The following sections will be devoted to considering the errors in estimating the wind and the Pasquill stability and what effect this has on ground level concentrations downwind from a large elevated source (like a power station chimney).

5. THE PROBLEM OF ESTIMATING THE WIND

Errors almost always exist in estimates of wind speed and direction. If you are concerned with whether or not you are being affected by the plume then wind direction is of prime importance - either you are in the plume or the wind direction is carrying the plume to one side. On the other hand wind speed is important if you are con-concerned with maximum ground level concentrations, wherever they may occur. Wind speed, as we have seen, affects the stability P as well as the dilution of the plume at source and the amount of plume-rise that occurs with bouyant plumes.

Most meteorological stations are equipped with wind vanes and anemometers which obviously must be of robust and long-lasting quality. The penalty for this robustness is that they are not highly sensitive (unlike research instruments) and in low wind speeds tend to be decidedly inaccurate. This is particularly significant for the estimation of the extreme P categories, A and G, which only exist with low wind speeds. At very low speeds the instruments do not even respond and at somewhat higher speeds the accuracy can be rather low. For example the so-called starting speeds for a wind vane are typically of the order 1 to 1.5 ms^{-1} whereas for an anemometer they are 3 - 4 ms^{-1}. A good meteorological observer will however apply his own judgement when making his readings and a likely final error in wind speed, below about 6 ms^{-1}, is only about 1 - 2 ms^{-1}. (Bad enough, you may say!).

The next problem is that the met. station is not directly beside your chimney but may be up to 50 or 60 kilometres away. Obviously winds do vary across the country in both speed and direction. C.G. Smith has recently done an analysis of the correlation between winds measured at neighbouring met. stations in three areas of the United Kingdom. All the areas are lowland areas. They are the low-

land area of central Scotland (which is subject to some topographical effects), south east England and, thirdly, East Anglia (when topographical effects are probably at a minimum). Figure 6 shows an interpretation of his results in terms of likely errors in speed and direction as a function of distance from the meteorological station. For example if this distance were 30km then errors of 1.35 ms^{-1} and 29^0 would be typical in the Scottish lowlands area. This assumes that your site is as well exposed as the typical meteorological station. If it isn't, then some further correction is necessary. If the effective local surface roughness can be estimated, a shot at this can be made, but is almost bound to be subject to error of at least 1 ms^{-1}.

This extrapolation from a neighbouring met. station can be particularly suspect if your site is subject to the influence of some marked local topography - a mountain, a valley, a city or a coastline. All these features tend to distort the airflow. An example of this is illustrated by the convoluted trajectories determined by Dr. Carpenter's rather sophisticated numerical meso-scale model for a warm June day when sea-breeze circulations were very evident. No further comment is required, I think, to emphasise the difficulties these effects pose.

So far we have considered only the problem of estimating winds at 10 metres in real time. Two further problems have to be considered. Firstly given the 10 metre wind, how do we find the wind at stack height? Smith and Carson (1974) have considered average relationships during the day, but at any one time, day or night, these can only provide a very rough guide. Errors of at least 2 ms^{-1} could be readily foreseen in this extrapolation, although at present I have no actual data to support this estimate.

The second problem arises if we wish to forecast the wind field ahead of time as we might for example if we were responsible for directing emergency procedures and services at the beginning of an accidental release of some hazardous airborne material from a chemical factory or nuclear power station which might persist over many hours. The obvious action is to consult your local meteorological forecasting office. Certainly there advice about likely trends in wind speed and direction will be invaluable. However it must be recognised they are faced with considerable problems in deciding upon the magnitudes of the changes that are likely to occur. Firstly they do not have a meso-scale model like Carpenter's model operationally available to them to cope with the effects of your local topography. Secondly they are bound to rely to some degree

on the results of the numerical forecasting model in their predictions. In many respects these models give excellent results, but are generally not too reliable in their forecasts of surface winds. This is because these winds are deduced from the pressure fields at a level about 1 kilometre up in the atmosphere. To relate the two, rather simple empirical rules are employed which must obviously be rather suspect. Figure 8 tabulates some of the errors determined by direct verification tests.

Overall then we can see we would be doing well in an operational situation if we could estimate the wind speed at stack height to within 2 - 3 ms^{-1} and a wind direction to within 30° unless we had some mean of directly estimating these, say by visual observations of the plume itself.

Although this section has been concerned with winds, we should end with a quick comment about errors in heat flux (and hence in P). Heat flux can be estimated quite readily to within $\pm$ 40 Wm^{-2}. In unstable conditions this is quite adequate and in conjunction with errors in wind speed is likely to yield typical errors in P of about one class at most. On the stable side the situation is rather harder, the range in H is smaller and perhaps the hardest questions to answer is whether or not some vestige of turbulence remains or whether it has been quenched and vertical turbulence is virtually non-existent, which often happens on quiet clear-sky nights.

6. ESTIMATING CONCENTRATIONS DOWNWIND FROM A LARGE CHIMNEY

Very many studies of power station plumes have been made and almost as many different formulae have been recommended to estimate plume rise and ground level concentrations. I hesitate as a mere meteorologist to enter into this arena, especially since I have made no survey of my own. Consequently I feel compelled to accept the findings of the very thorough study carried out by C.E.R.L. and C.E.G.B. described in the literature in several papers by, amongst other, Dr. D.J. Moore. I will accept their data and their formulae as being the best, or amongst the best available at the present time. Their equations are necessarily rather complex (see for example Moore, (1974), Advances in Geophysics, p.220). It is probably over-bold of me to try to simplify these, but it has been my experience that good estimates can be obtained very quickly using the simplified scheme set out in Figures 9 - 13. It should be stressed that these estimates are based on actual measurements made round real power stations in the UK. Figure 9 gives an estimate of

the average maximum ground level concentration, $\overline{C}_{max}$ given the output of heat Q_H (in MW) and the stack height h_s (in metres), averaged over all meteorological conditions. Q_H can be estimated if the electrical output of the station is known:

$$Q_H \approx \frac{1}{6} \ Q_{elect.} \text{ in MW.}$$

We have assumed that typically the output of sulphur dioxide Q (gs^{-1}) is related to Q_H by:

$$Q \approx 25 \ Q_H$$

As the equation in the Figure shows this assumption is not necessary if Q is otherwise known.

Figure 10 gives the best estimate of the actual maximum concentration C_{max} in a given (u,P) situation once $\overline{C}_{max}$ is found. The behaviour of the C_{max} contours incorporates the effect of u and P on plume rise, dilution at source and depth of the mixing layer in a direct empirical way through the real data on which it is based.

Figure 11 shows how this maximum concentration varies with sampling time. This allows for the effect of typical wind direction changes due to changes in the synoptic, meso-scale and small scale wind fields, and allows for the finite width of the plume at any instant.

Figures 12 and 13 provide equivalent information x_{max}, the distance downwind in kilometres where the maximum ground level concentration is expected to occur.

Figure 14 illustrates the downwind distribution of concentration relative to C_{max} and x_{max}.

Overall this scheme provides a quick and reasonably accurate means of estimating the concentration field based on Moore's more detailed analysis of this problem.

7. ERRORS IN ESTIMATING C_{max} AND x_{max}

As we have already seen one major source of error is likely to arise from uncertainties in the wind speed u at stack height and in the Pasquill Stability P. Figure 15 uses our estimates of these errors in conjunction with the scheme for estimating C_{max} and x_{max} just outlined to estimate likely errors in C_{max} and x_{max}. Most of the errors are acceptable although errors in C_{max} in stable

conditions are, as one might expect, rather large.

Figures 16 and 17 show that in practice there are other sources of error which are not explained solely by errors in u and P. These arise from a variety of causes. One major cause is that emissions from chimneys are difficult to estimate accurately (due to variability in sulphur content of the fuels and variability in time in fuel usage).

Another source of error which on many occasions must be very important is variability in the internal structure of the boundary layer. This structure arises in an evolutionary sense during the upwind passage of the airmass over terrain with complex time-varying thermal properties and roughness. In particular, inversion heights and strength are quite variable especially at night. If it was expedient to do so, some valuable information on the nature of these inversions can be obtained from data collected during routine radiosonde ascents at one of the few radiosonde stations round the UK.

Another variable phenomenon, more typical of daytime conditions, is illustrated in Figure 18. Large Ekman-type rolls orientated with their axes more or less parallel to the wind, can fill the boundary layer. The circulation associated with these rolls can draw in a plume and carry it upwards and spread it out at the base of the capping inversion. Such behaviour is bound to considerably affect ground level concentrations.

The final cause of error which will be referred to is concerned with the effect of wind direction changes. Some measure of the synoptic component of these changes is shown in Figure 19. The angular spread caused by changes in the synoptic meteorological field is of necessity a function of the time over which the plume is sampled. Geostrophic wind directions have been sampled over a two year period and analysed in terms of sampling time T. Figure 19 shows that for T = 1 hour, say, the average swing in the wind is 2^{0} but on 10% of occasions the swing exceeds 8.5^{0}. For 10 hours the mean is 20^{0} but 10% lie above 80^{0} and 10% below 5^{0}. Some correlation must exist with wind speed and synoptic situation but this is a subject for future research. Nevertheless it is clear this can be an important source of variability in C_{max} for given Q_H, h_s, u and P.

Overall then it is not surprising that estimating C_{max} and x_{max} is a formidable problem. Over flat terrain estimates of C_{max} within a factor of 2 (for t = 1 hour) are as much as we can hope to achieve.

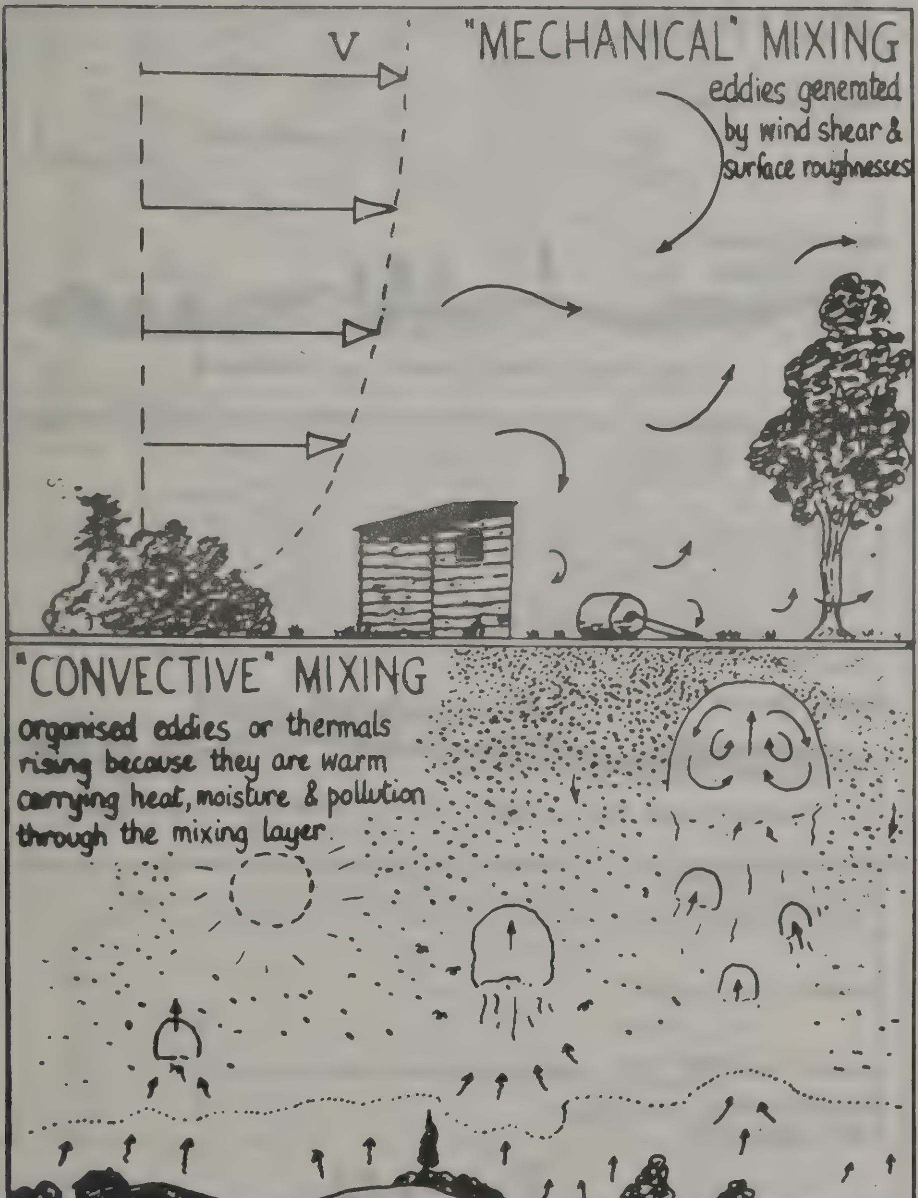

V
"MECHANICAL" MIXING
eddies generated by wind shear & surface roughnesses
"CONVECTIVE" MIXING
organised eddies or thermals rising because they are warm carrying heat, moisture & pollution through the mixing layer

FIGURE 1.

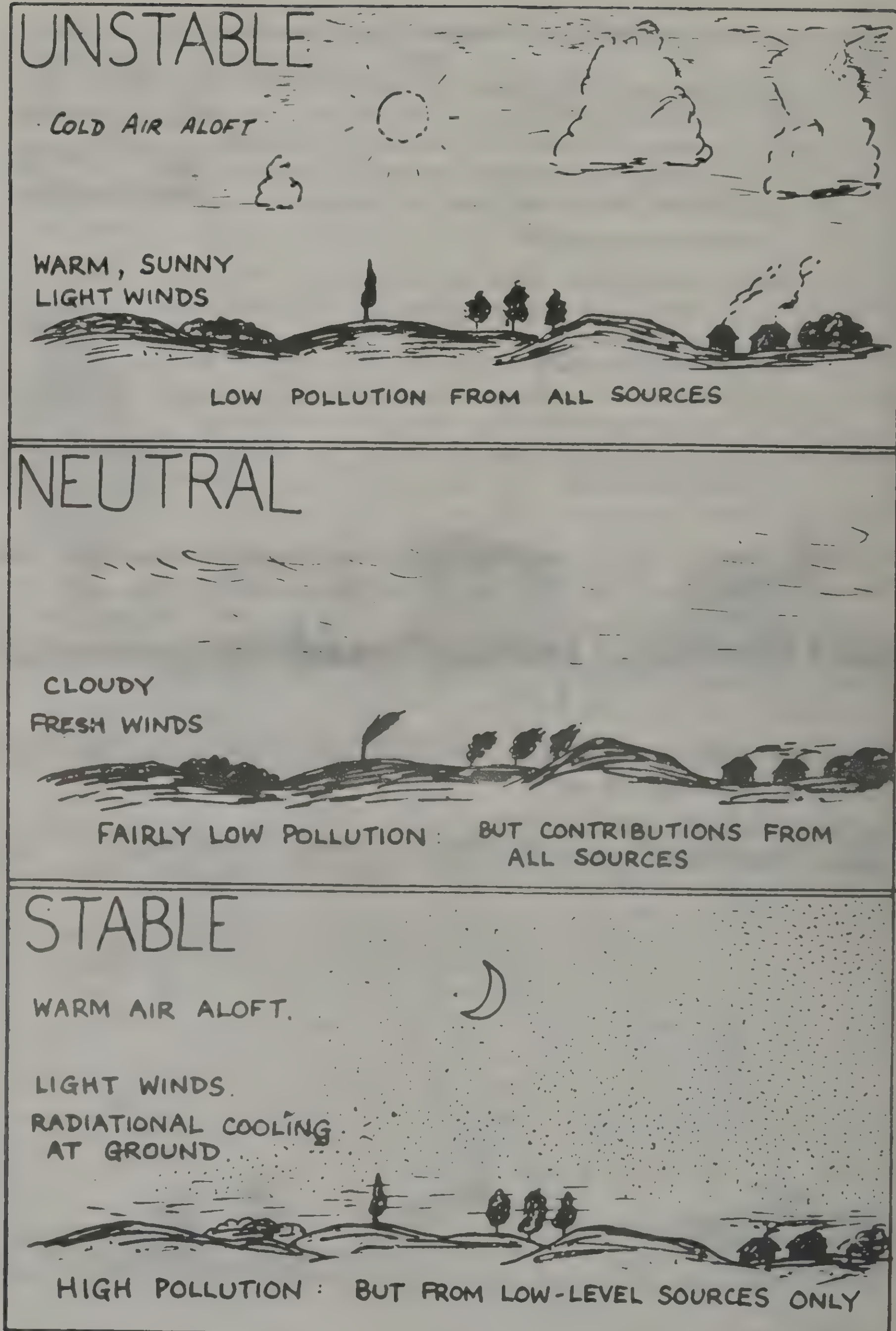

UNSTABLE
COLD AIR ALOFT
WARM, SUNNY
LIGHT WINDS
LOW POLLUTION FROM ALL SOURCES
NEUTRAL
CLOUDY
FRESH WINDS
FAIRLY LOW POLLUTION : BUT CONTRIBUTIONS FROM ALL SOURCES
STABLE
WARM AIR ALOFT.
LIGHT WINDS.
RADIATIONAL COOLING AT GROUND.
HIGH POLLUTION : BUT FROM LOW-LEVEL SOURCES ONLY

FIG. 2.

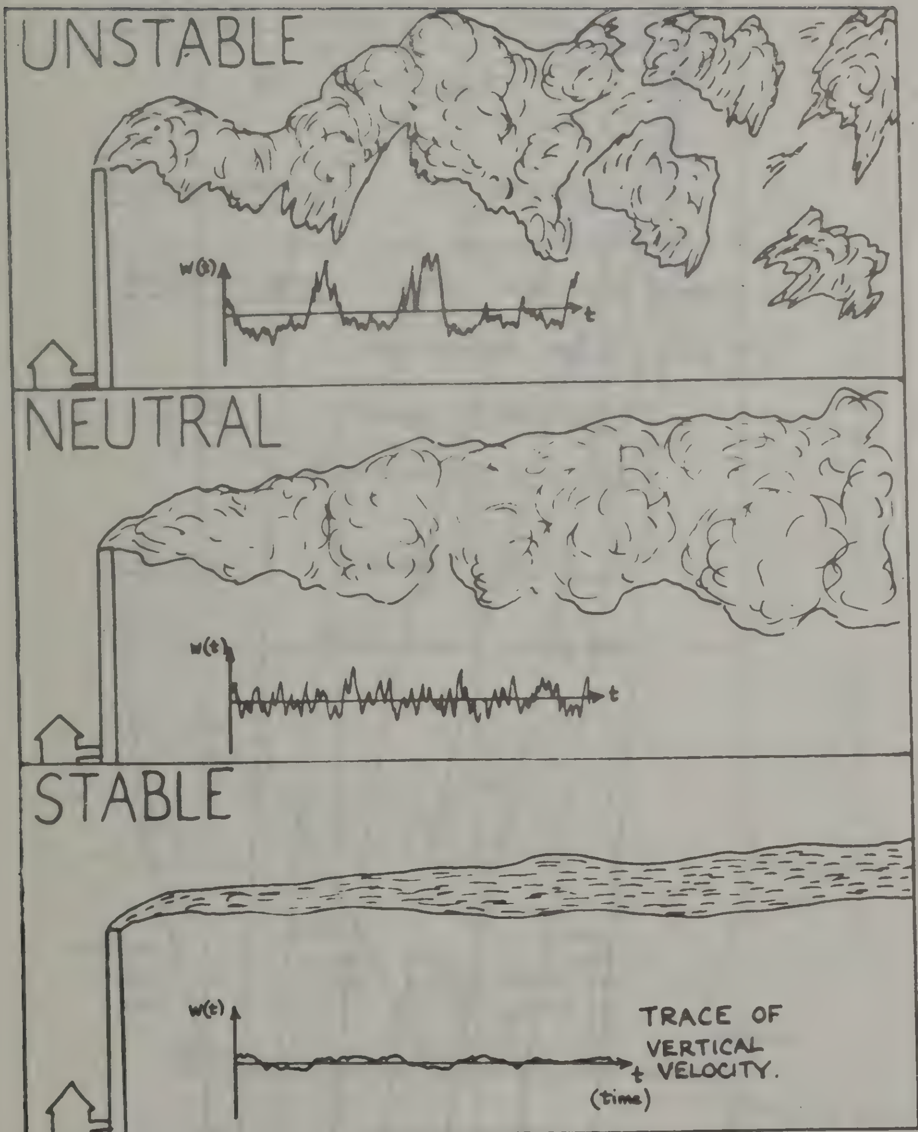
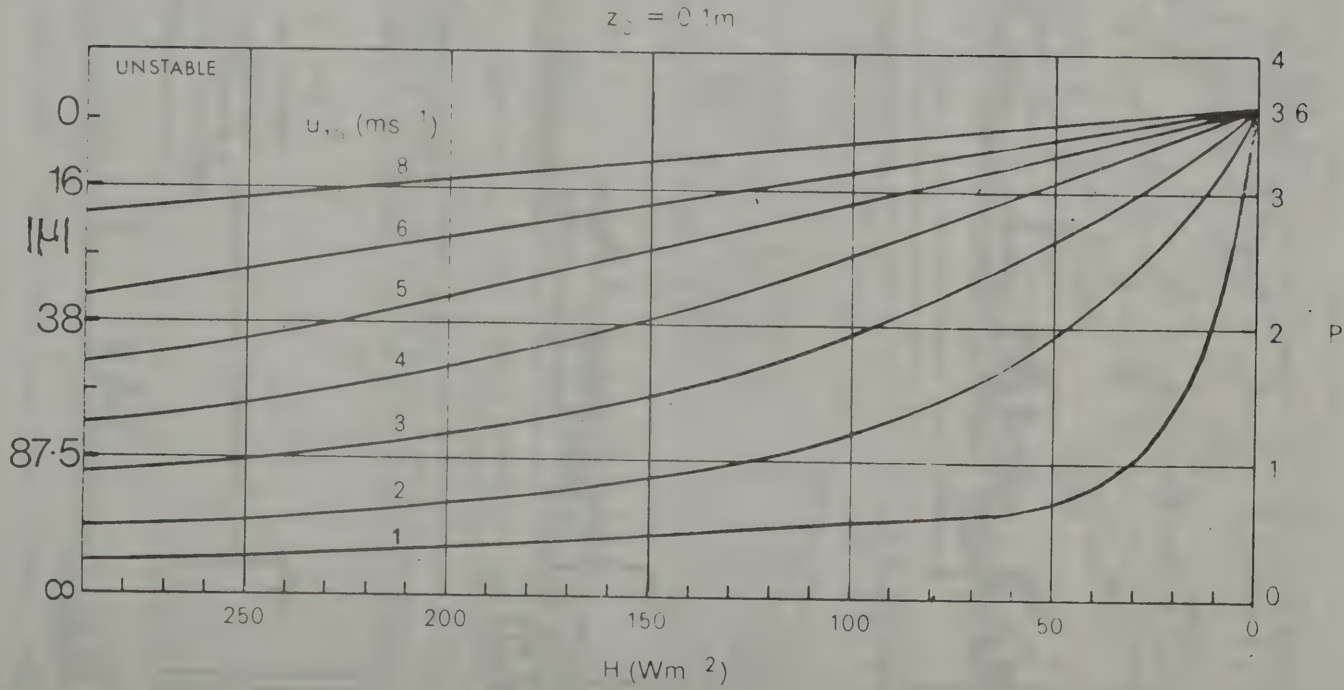

UNSTABLE
w(t)
t
NEUTRAL
w(t)
t
STABLE
w(t)
TRACE OF
VERTICAL
VELOCITY.
t
(time)

FIG. 3.

FIGURE 4a. The revised scheme for P based on lines of constant μ



SURFACE SENSIBLE HEAT FLUX

H (watts/m^2)

Typical values: (at midday)

Winter's day: −20 very cold ground

nice winters day +50 Wm^{-2}

Spring: cloudy: 40 Wm^{-2}

clear skies: 200 Wm^{-2}

Summer: cloudy: 80 Wm^{-2}

clear skies: 300 Wm^{-2}

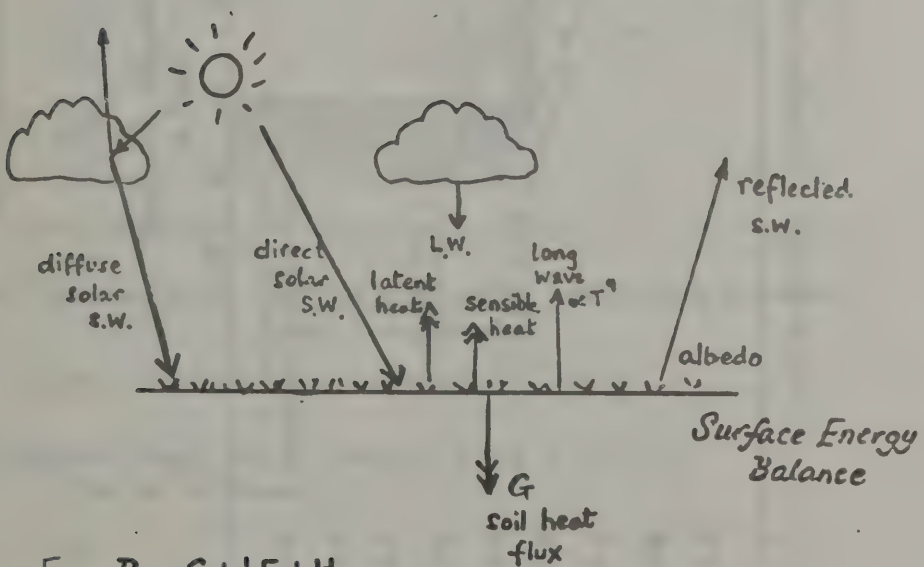
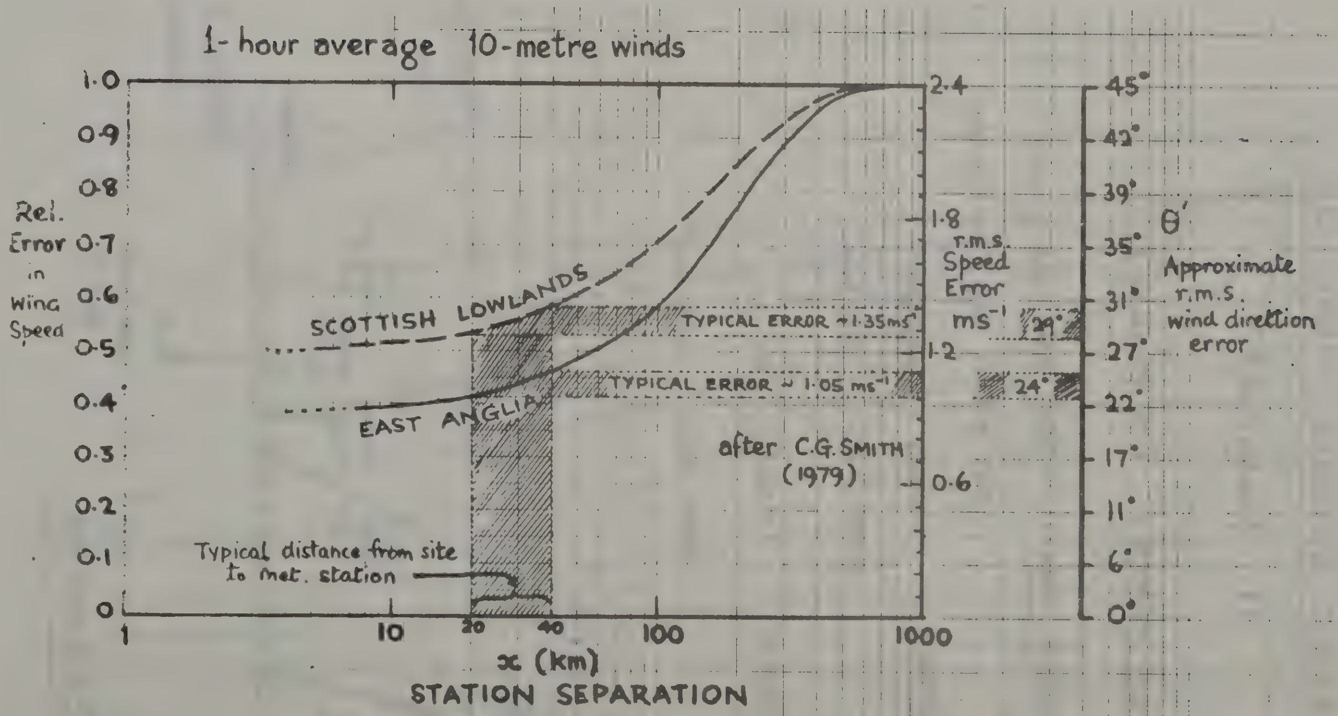
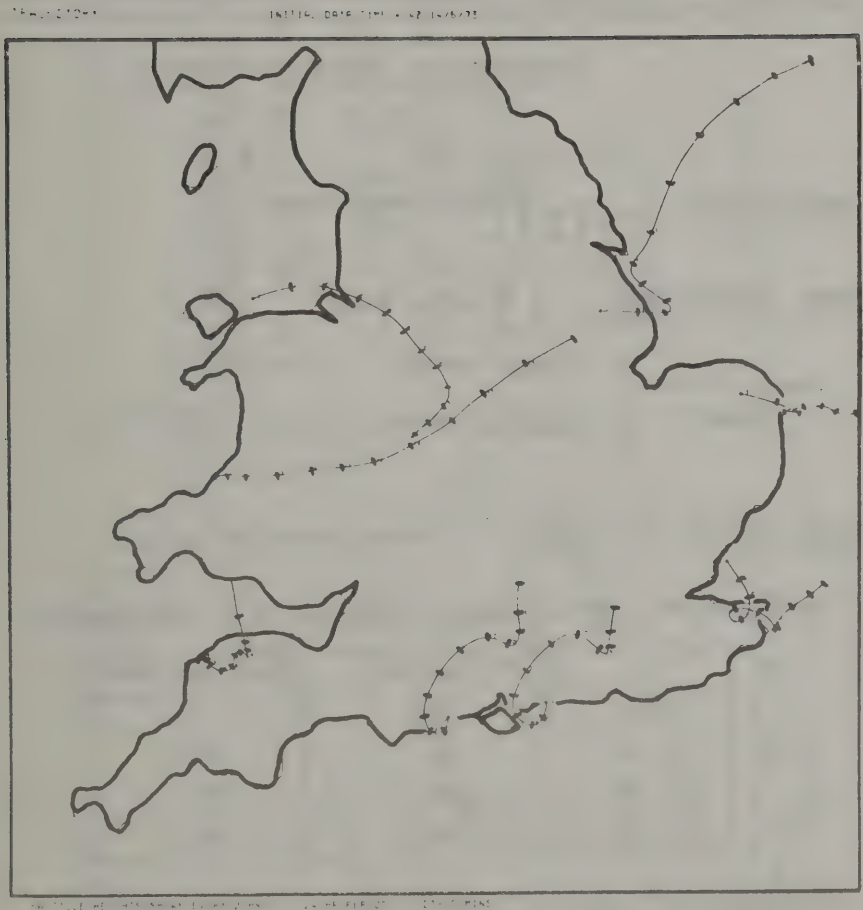


FIG. 5 $R_n = G + LE + H$



1-hour average 10-metre winds
Rel. Error in Wind Speed
SCOTTISH LOWLANDS
EAST ANGLIA
TYPICAL ERROR ~1.35 ms⁻¹
TYPICAL ERROR ~ 1.05 ms⁻¹
after C.G. SMITH (1979)
Typical distance from site to met. station
x (km)
STATION SEPARATION
r.m.s. Speed Error ms⁻¹
θ′
Approximate r.m.s. wind direction error
29°
24°

Fig. 6



K. CARPENTER'S NON-HYDROSTATIC MESO-SCALE MODEL WITH TOPOGRAPHY

NOTE STRONG SEA-BREEZE ACTIVITY

[Release time 04 Z . Marks every 2 hours]
Run for 24 hours

Fig. 7

NUMERICAL 10-LEVEL OPERATIONAL FORECASTING MODEL

ERRORS IN WIND FORECASTS

OVER LAND : no data available

OVER NORTH SEA : 10 metre winds :

up to 24 hrs ahead { speed errors : ~ $2.5\ ms^{-1}$
direction errors : $15° - 30°$

OVER NORTH ATLANTIC : wind direction errors :

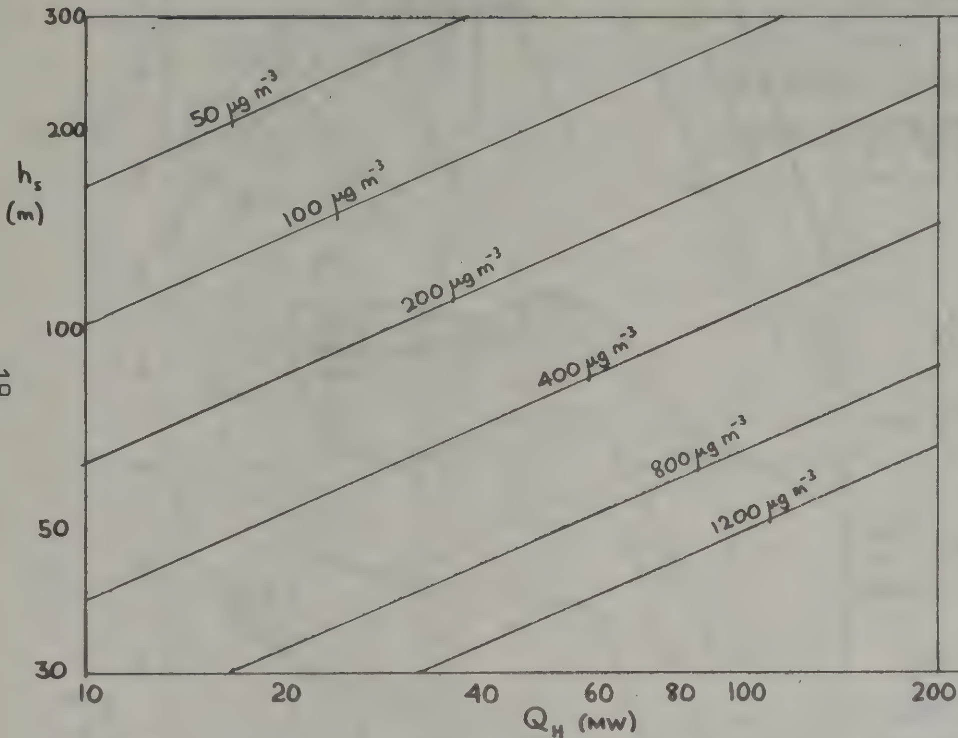
Verification against ocean weather ship observations :

	Forecast error	Persistence error
T + 0	25°	–
T + 12	37°	50°
T + 24	41°	65°
T + 36	48°	70°

Verification against mobile ship observations.

	Forecast error	Persistence error
T + 0	39°	–
T + 12	41°	58°
T + 24	44°	74°
T + 36	48°	82°

Fig. 8



Average maximum ground-level concentration $\overline{C}_{max}$ of SO_2

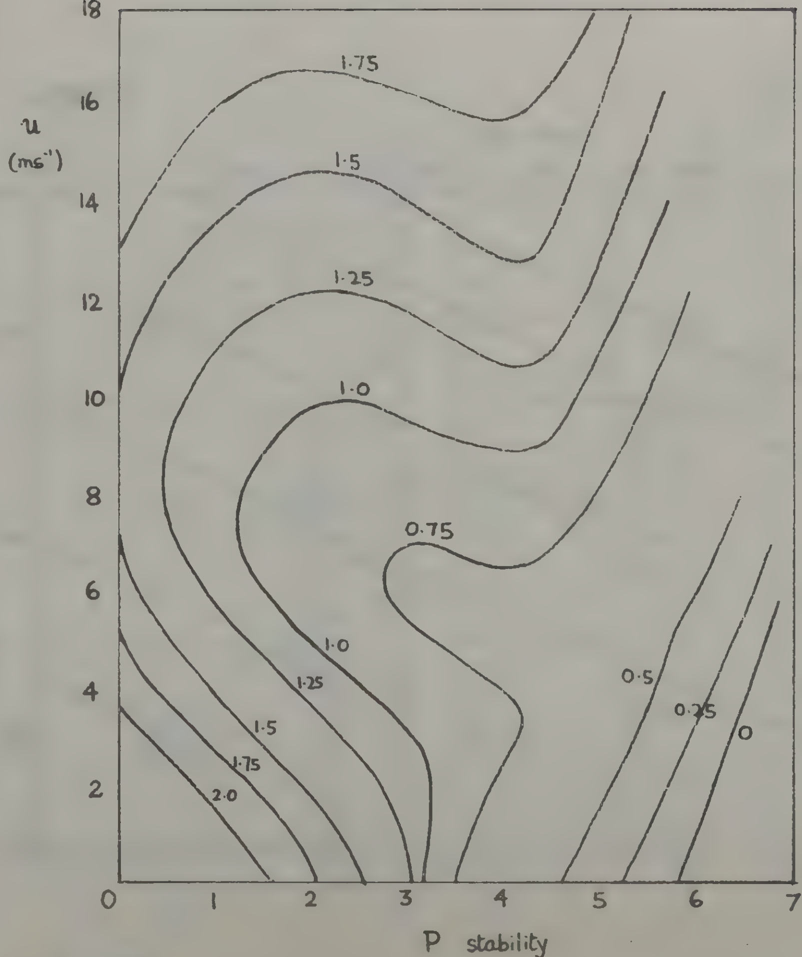
for Q_{SO_2} $(gs^{-1}) = 25\ Q_H$ (MW)

$$\overline{C}_{max} = 700\ Q_{SO_2}\ Q_H^{-0.37}\ h_s^{-1.43}$$

concentrations averaged over 1 hour

$\frac{C_{max}}{\overline{C}_{max}}$	% of time exceeded
1	35 %
1·5	19 %
2	11 %
3	4 %

Figure 9



CONTOURS OF

$$\frac{C_{max}}{\bar{C}_{max}}$$

where :

$$\bar{C}_{max} \approx 700\, Q_{SO_2} Q_H^{-0.37} h_s^{-1.43}$$

in $\mu g\, m^{-3}$

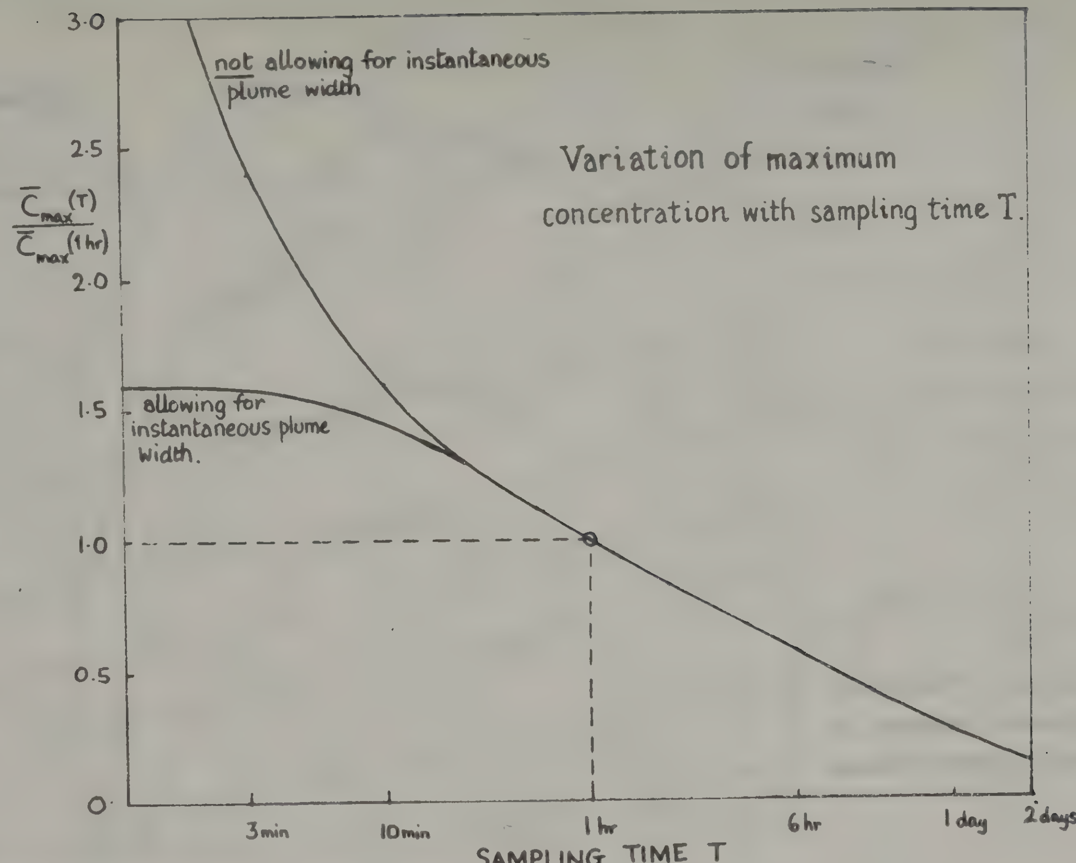
and Q_{SO_2} is in $g s^{-1}$ (output of SO_2)

Q_H is in MW (output of heat)

h_s is in metres (stack height)

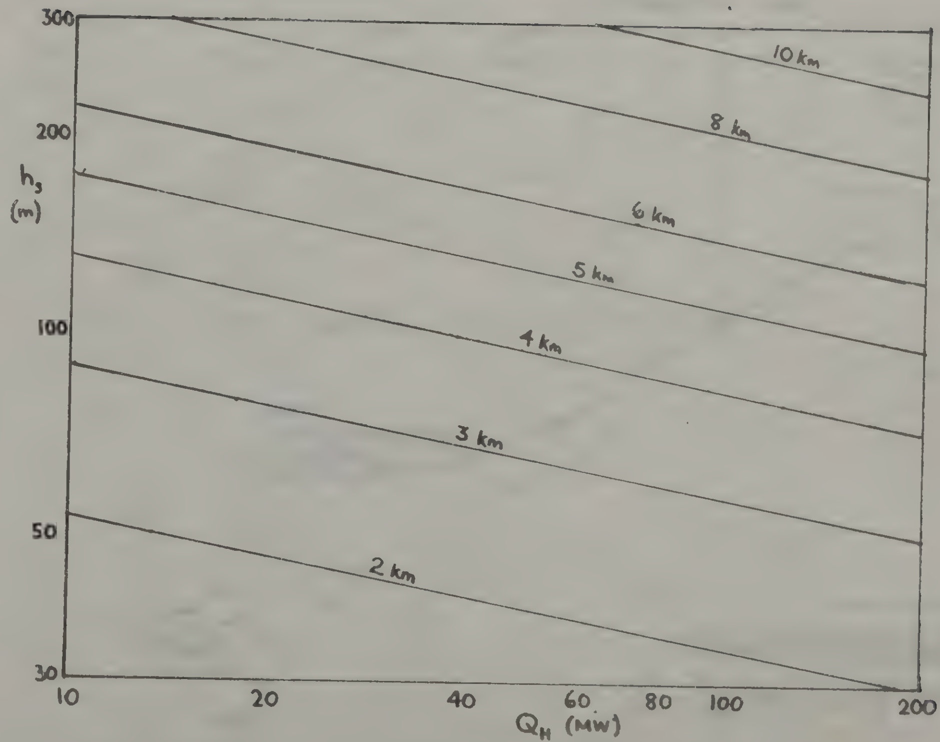
Takes into account the typical variation of Q_{SO_2} & Q_H with u & P. Curves based on Moore's data for Northfleet & Tilbury P.S.

Figure 10.



3.0
2.5
$\frac{\bar{C}_{max}(T)}{\bar{C}_{max}(1\,hr)}$
2.0
1.5
1.0
0.5
0
not allowing for instantaneous plume width
allowing for instantaneous plume width.
Variation of maximum concentration with sampling time T.
3 min
10 min
1 hr
6 hr
1 day
2 days
SAMPLING TIME T

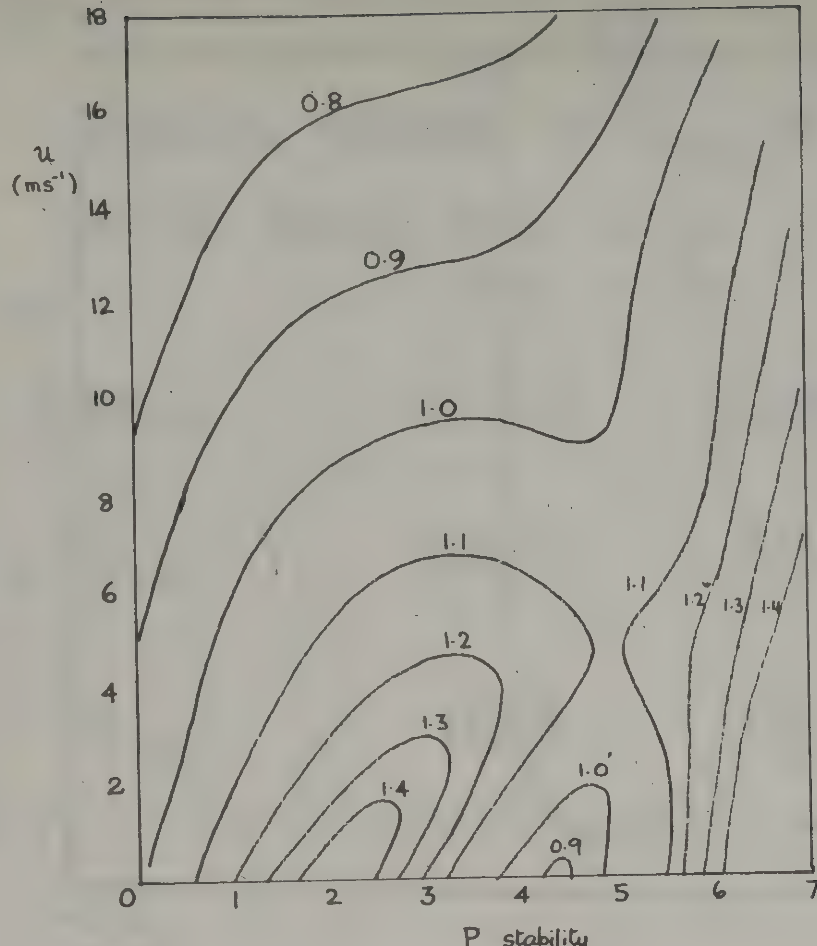
Figure 11.



Average distance downwind $\bar{x}_{max}$ of maximum ground-level concentration of SO_2

$$\bar{x}_{max} = \frac{1}{15} Q_H^{0.15} h_s^{0.77}$$

Figure 12.



CONTOURS OF

$$\frac{x_{max}}{\bar{x}_{max}}$$

where :

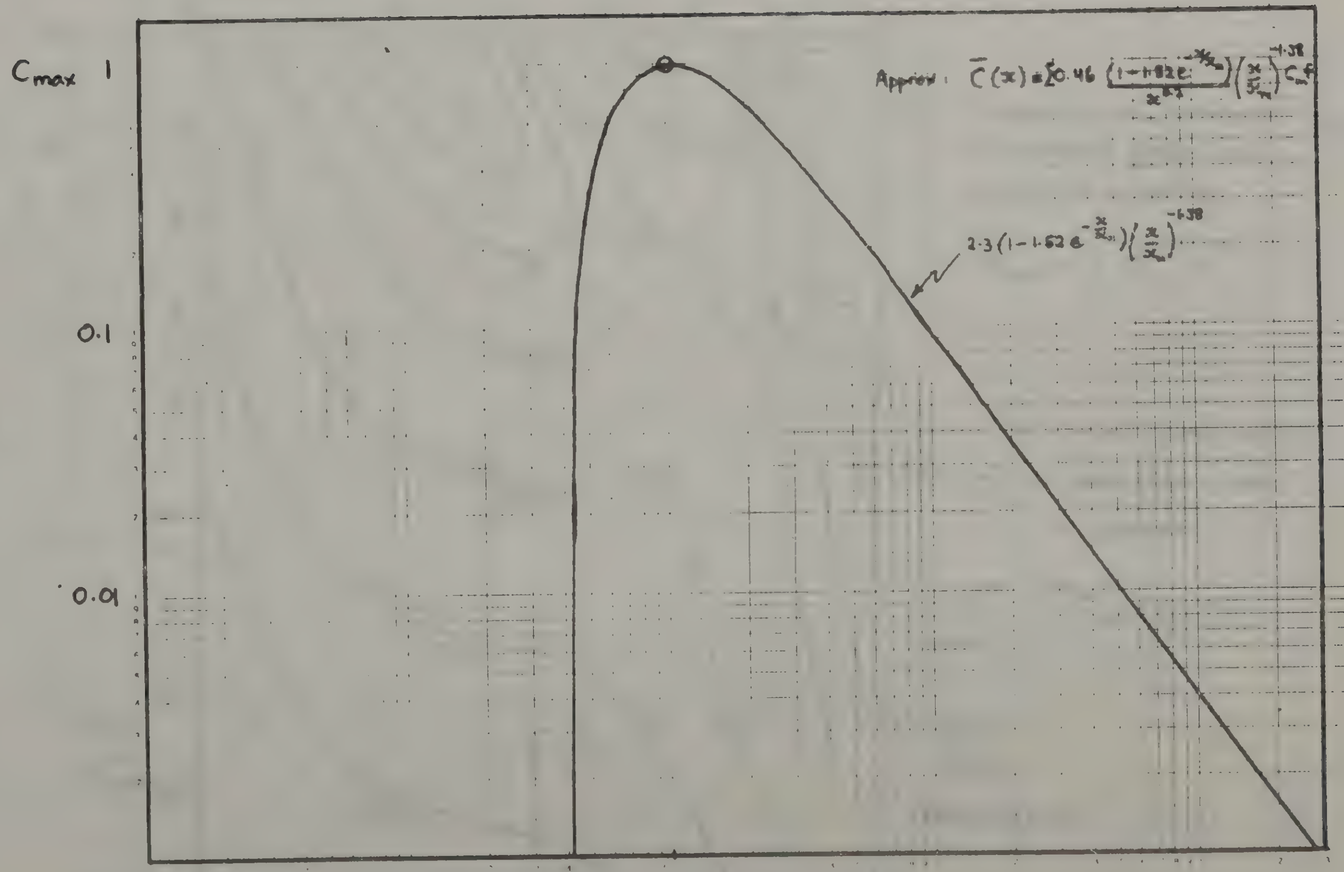
$$\bar{x}_{max} = \frac{1}{15} Q_H^{0.15} h_s^{0.77}$$

in kilometres

and Q_H is in MW (output of heat)

h_s is in metres (stack height)

Figure 13.



C_{max}
1
0.1
0.01
$2 \cdot 3\left(1 - 1 \cdot 52\, e^{-\frac{x}{x_m}}\right)\left(\frac{x}{x_m}\right)^{-1.38}$
x_{max}

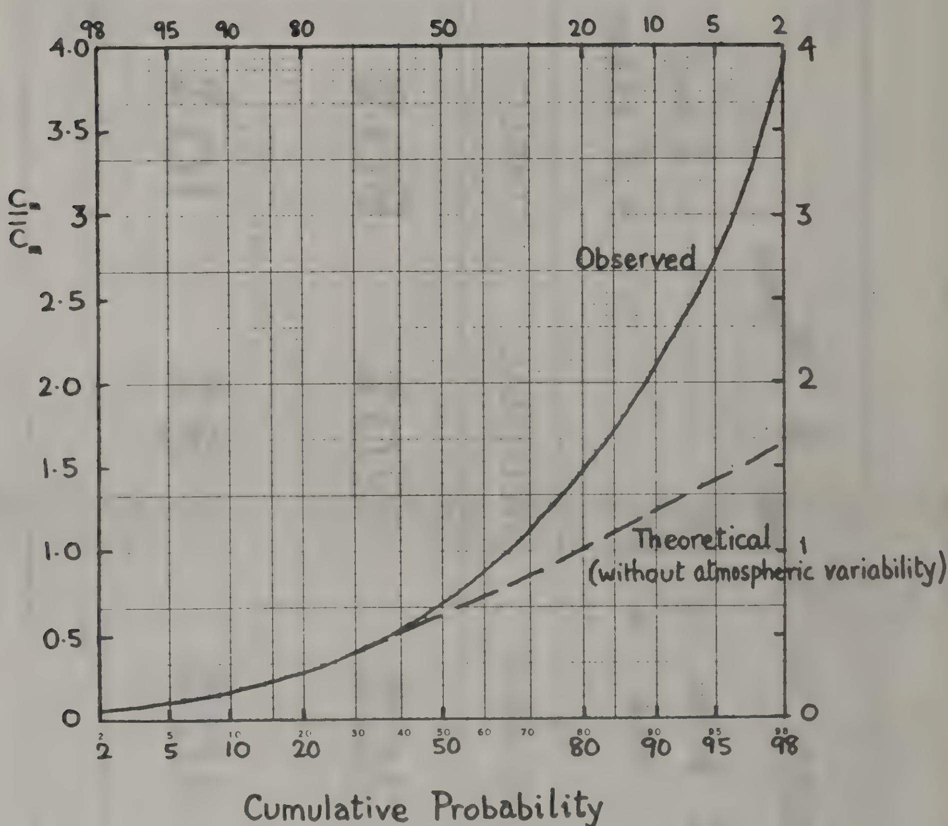
Figure 14

TYPICAL ERRORS IN C_{max} & x_{max}

due to typical error in u .... $\sim 2\ ms^{-1}$
and in P .... ~ 1 class

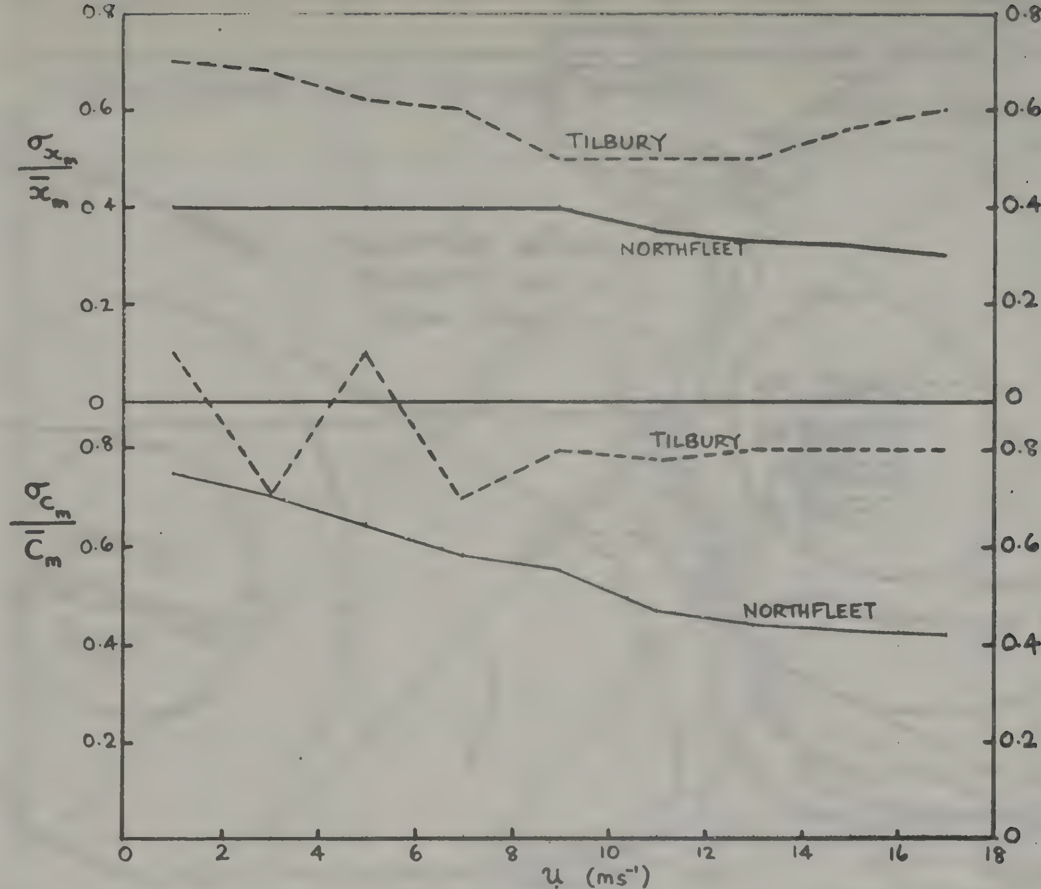
% ERROR	UNSTABLE	NEUTRAL	STABLE
C_{max}	25%	20%	80%
x_{max}	10%	8%	10%

FIG. 15.



This figure shows that variability in maximum ground-level concentration arising from variability in boundary layer structure and turbulence dominates over that due to variations in $C_{max}(u,P)$.

Figure:16



All stabilities.

Figure: 17

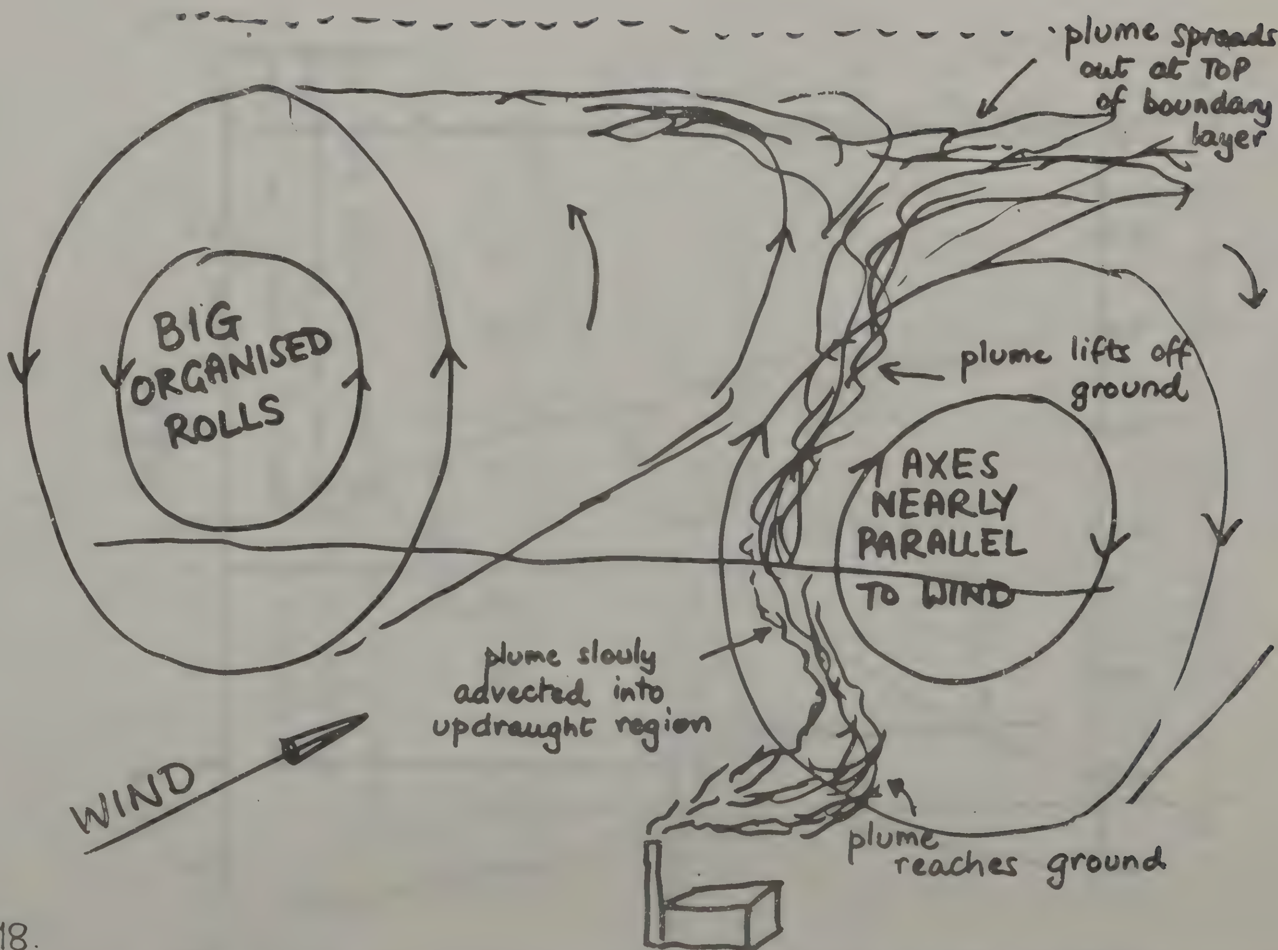

plume spreads out at TOP of boundary layer
BIG ORGANISED ROLLS
plume lifts off ground
AXES NEARLY PARALLEL TO WIND
plume slowly advected into updraught region
WIND
plume reaches ground

FIG. 18.

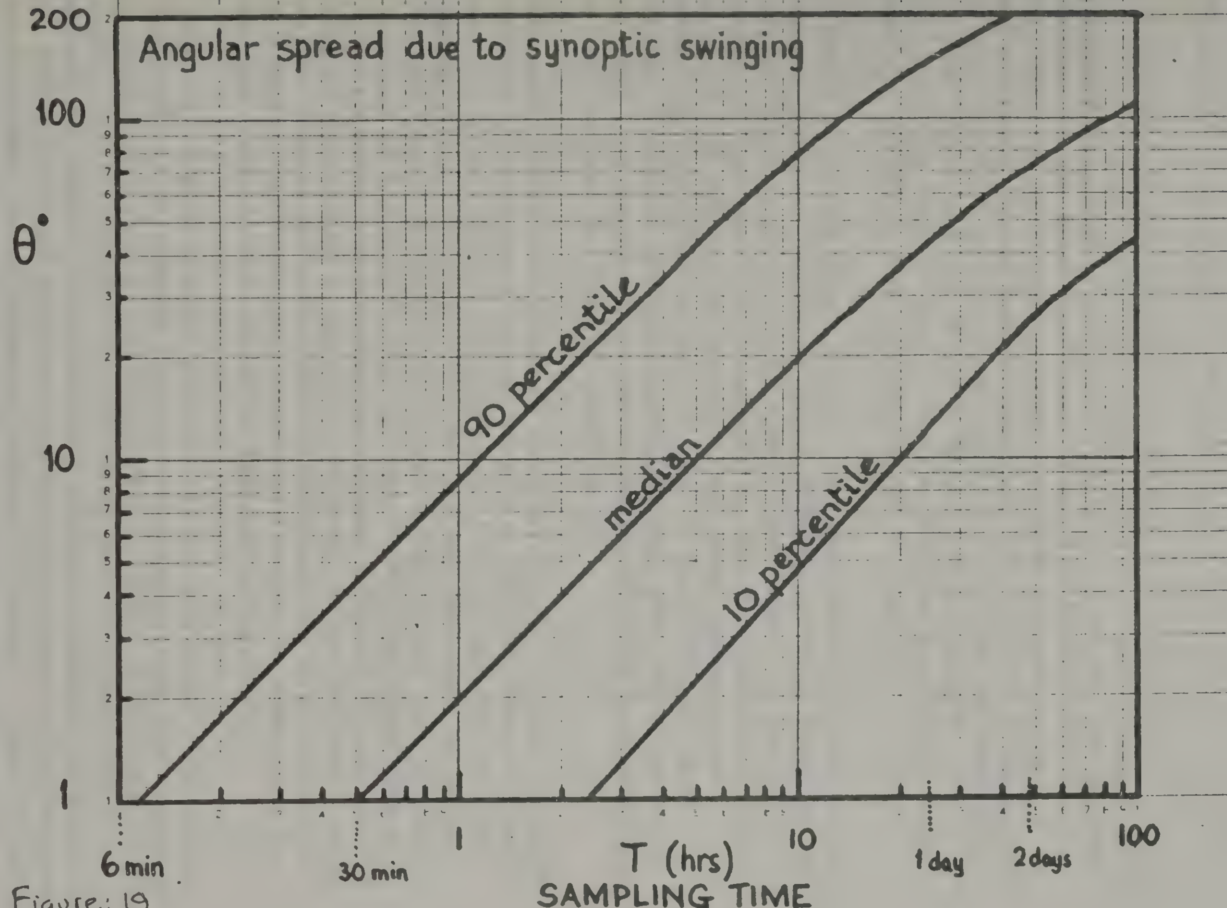

Angular spread due to synoptic swinging
200
100
θ°
10
1
90 percentile
median
10 percentile
6 min
30 min
1
10
1 day
2 days
100
T (hrs)
SAMPLING TIME

Figure: 19

SESSION 2

THE WEATHER - Jack Scott, Meteorological Office

THE ACCURACY OF FORECASTING POLLUTION - Dr. F.B. Smith,
Meteorological Office

Professor R.S. Scorer (Clean Air Council), opening the discussion, thanked the two speakers for their excellent prsentations. To supplement their theses he added that the atmosphere in its natural state is continually recycled and consists of"pollution" in the form of the waste gases of life. All the nitrogen and all the oxygen was put there by biological processes. The same could be said of nearly all the CO_2 and some of the water vapour. Certainly 99% had originated in that way.

In addition to the gases most of the particulate matter was of natural origin. Professor Scorer showed slides of trees in the Isle of Wight stunted on one side by the impact of sea salt spray, of dust devils in Kenya and Uganda, of desert dust blown up to 20,000 feet in California, and of the Sahara desert completely obscured from aerial view by particles of desert origin. So dense was this extensive dust that the black smoke from the very large oil flares in Southern Lybia could scarcely be seen and was trivial in comparison.

That same Sahara dust haze was next shown over Greece, to where the Sirocco wind had carried it, but it now had cumulus cloud among it since the air had been moistened by passage over the Mediterranean. His next slide showed the Harmattan at Suez: this was formed by organic dust particles ground into a very fine haze by the desert sand so that it had the appearance of a fog. A satellite picture then showed dust carried across the coast of Mauritania circulating round a cyclone between Madiera and the Azores: on that occasion there was red rain caused by this dust in the Hebrides, which was the second time there had been red rain of this origin in Britain in 15 years.

Forest fires were another form of natural pollution and slides were shown to illustrate how the smoke was quickly carried up to cloud base but very little beyond that height: individual cumulus clouds left a residual tower of smoke when they evaporated. However in order to be cleaned out of the atmosphere this pollution did eventually have to be carried into the clouds and rained out, and Professor Scorer showed a picture of layers of smoke in among the clouds at Utah. A rain storm at the Great Salt Lake illustrated that the salt was all of atmospheric origin.

The problem of car exhaust was illustrated by a picture taken in Los Angeles with dense pollution below an inversion. The same was illustrated in Santiago, Chile, but in less dense form. However natural photochemical smog was illustrated by a picture of the clean air at Darjeeling after a rain storm with a blue haze over the forests. This was caused by the action of sunshine on the hydrocarbon vapours emitted by the trees.

Finally Professor Scorer showed a picture of the tropopause with the clean stratosphere above. Nevertheless nature put a lot of pollution into the stratosphere. For example mother of pearl clouds were produced on clouds of sulphate seen from time to time at twice the height of the tropopause: they had remarkable trails of cloud formed of hydrated sulphate particles streaming out of the evaporating edge of wave clouds. The picture shown had been taken in Norway but layers of sulphate had been detected in the stratosphere in Hawaii, where water clouds at that level are not seen.

Mankind, said Professor Scorer, was merely extending his own personal biological activity when he used fuel and there was nothing unnatural or to be ashamed of in nearly all the pollution emitted to the atmosphere: our task was to ensure that it was always adequately diluted, and Mr.Scott and Dr. Smith had given a great deal of information about how this end could be, and indeed largely was achieved.

Mr. N. Parkinson, (Selby District Council) said that his wife was a great admirer of Jack Scott and had asked him to put a question to Mr. Scott at the Conference. She wanted to know why, in the summer months during periods of high pressure, there were so often disappointingly dull days with uniformly grey skies; without rain but also without sun. It was commonly thought that high pressure invariably produced sunny weather and blue skies.

Mr. J. Norton (Leeds City Council) said that the speakers had talked about the variability in being able to forecast the weather. He said that Environmental Health Officers had a similar problem of variability in assessing chimney heights. Originally they had to use the 2½ times rule of the CEGB; then there was the cold gas formula when of course Bosanquet's hot gas formula should have been employed, but the lack of information on planning

made it very difficult to get the information within planning time, so that there was a variability in the resultant stack heights. The Memorandum on Chimney Heights gave some guidance to EHO's when dealing with stack heights, but the essential ingredient to overcome the problem of variability was to get good combustion.

Mr. H.I. Fuller (Chairman of NSCA Council) asked a question from the chair, addressed basically to Barry Smith, who had undoubtedly noticed Professor Scorer's pictures of rainout; that is, the effects of rain bringing the pollution down to ground level. Dr. Smith had spoken of the dispersion of pollution in the wind and had talked about the uncertainties introduced by not knowing the wind speed or heat flux very accurately. But taking Professor Scorer's slides into account, Mr. Fuller felt that rainout, too, was very happen chance. Rain seemed to occur more or less as it pleased and in spite of the frontal rain that Jack Scott had referred to, there were still showers and bright intervals in between. He asked if Dr. Smith would comment on the effects of the rather haphazard nature of precipitation.

Cllr. J.M. Bramley, (Selby District Council) explained that he was living in a very rural area where they got the weather forecast like anybody else (although he thought it was quite often wrong).

However, he was living about 1½ miles south of a railway line and invariably if he went to bed and could hear these trains running, there would be rain before morning. He asked Jack Scott to explain the phenomenon.

Mr. J. Beagle (London Borough of Hammersmith and Fulham) asked whether, with modern forecasting methods, it was possible to detect whether sulphur dioxide carried over long distances from the U.K. was affecting Scandinavia i.e. Norway and Sweden.

Mr. T.A. Dorling, (Warren Spring Laboratory) said that the essence of good weather forecasting was to get the meteorological information to the central forecasting centre as rapidly as possible. He asked Mr. Scott to describe the methods used to transmit information internationally; he wondered whether it was done

automatically, in a form which could be handled directly by the computer.

He suggested that in the future, local information about certain pollutants, e.g. SO_2, might be transmitted with the meteorological information, which could be of value in following the long range transport of air pollutants.

REPLIES TO QUESTIONS

Mr. Jack Scott, replying, referred to Mr. Parkinson's question on anticyclones, and said that an important feature was that both types of inversion could occur in an anticyclone. Although in mid-summer anticyclones might be the thing everyone hoped for, especially if it was holiday fornight coming up, in autumn , winter and spring, those interested in pollution ought to be severly worried by anticyclones, because the associated inversions could produce the worst pollution incidents. Almost all the UK's fogs occured in such situations in the autumn, winter and spring period, underneath anticyclones. Frosts were also produced, because of the air cooling down near to the ground.

Turning to Mr. Dorling's question about the transmission of meteorological information, Mr. Scott referred to earlier comment that international weather forecasting had begun in the middle of the last century. Fortunately, the awareness and the science or the understanding of the science had grown at exactly the same time as the telegraph had arrived; that had been the first means of transmission, the means by which international exchange of information first took place. The pioneer meteorologists had realised that what happened in one part of the world or country depended on what was happening in another part of the world or country, and recognised that it was essential to know very quickly in one place what was happening elsewhere. Then radio had arrived, and was still being widely used. Since radio, forecasters had been really dependent upon the teleprinter, and for many years the teleprinter had been the real means of communications, not only within a country but between countries, so that teleprinters and radios together were the means of communication, and they both suffered from the problem that it took time to transmit a message from one to the other, so that to receive the information of the weather over the whole of the northern hemisphere took a great deal of time, even though the

updated teleprinter system was computerised all round the world (another indication of the international co-operation between meteoroligists under the auspices of the World Meteorological Organisation. In 1873 the first International Meteorological Organisation had been founded, and the international exchange of information was all arranged at that time). Teleprinters had been computerised so that they could take in and transmit information at about nine times the speed of a normal office teleprinter. He explained that the information came up rather like a computer print-out in big batches, but at nine times the speed. The teleprinter tapes coming in could be fed directly into a computer, the computer tape being cut as the information was coming in without anyone actually reading it in the meantime. The whole system was automated all around the world. To illustrate the aspect of international co-operation, Mr. Scott said that some 3 or 4 years previously a delegation from China had visited the Bracknell HQ long before the UK was officially speaking to the Chinese as amiably as in 1979. The Chinese delegation wanted to build a telecommunications centre similar to that at Bracknell, within the international set-up.

The latest development was the transmission of weather maps and other meteorological information on the same sort of machine as that receiving pictures from satellites. These, called 'facsimile machines', could transmit pictures over land line or radio wave length, so that the finished weather chart, drawn up on the basis of information from Russia, for instance, could be transmitted back to Russia on a 'facsimile machine', or broadcast to any country which wanted to pick it up. Not only could the UK broadcast what the computer said the chart would look like in 24, 48 or 72 hours' time, but similar information could be received from other countries, such as America and West Germany.

Turning to Cllr. Bramley's question, Mr. Scott said that he did not agree with the statement that weather forecasters were so often wrong. He admitted he might not be an entirely impartial judge, but he said that the essence of listening to a weather forecast or using a weather forecast was to use the right forecast. There was no point in planning activities for an afternoon on the basis of what had been shown on the television the previous evening. Equally, there was really no point in basing the afternoon's plans on a weather forecast published in the morning's newspaper, because that forecast had probably been prepared before the previous evening's television forecast anyway. But the real way of using weather information was to look in the front of the tele-

phone directory, find out where the local forecasting office was and ring that local forecast office for information. It was important, especially for those working in an official capacity who might need meteorological information, not to rely on recorded telephone weather information. Those working officially on behalf of a local authority, for example, should contact their local manned forecasting office and put a specific question to the forecaster, who would address himself to that question. People should not ask vaguely "what's the weather going to be like in the north of England this evening", if they wanted to play tennis in Doncaster that evening, because they would get a vague answer to such a general question. Mr. Scott confessed that in all the national broadcasts, vague answers in that sense were given because such a very wide area was being dealt with; but if people wanted to pin point a spot, and asked the real question, he could guarantee that the accuracy of the resulting forecast would be startling.

On Cllr. Bramley's point about expecting rain after hearing the trains $1\frac{1}{2}$ miles from his house, Mr. Scott advised him to apply the same tests to hearing the trains as he had presumably done to the accuracy of the Met. Office's forecasts. He should log the times on which he heard the trains, and check whether it actually rained the next day. It would probably be found to be a rather inexact correlation. Mr. Scott could not think offhand why rain should follow enhanced sound from the north.

Dr. Barry Smith, replying to the discussion, said that most of the questions directed to him had been concerned with the long range transport of pollution, and he would answer these, although not perhaps in the order in which they had been put. First, he said that he was quite sure that sulphur in one form or another, whether as sulphur dioxide or as sulphate, was being transported from the UK and was affecting Scandinavia. The precise amount that was being transported was open to question. A very large project had been carried out, from 1971 to 1977, in which a lot of work had been done on that very problem, and he thought that at the end of this work, he and the other participants in the project had been reasonably confident that as far as the sensitive areas of southern Norway were concerned, something of the order of 20 to perhaps 30 per cent of the sulphur landing in that sensitive area had its origin in the UK. There had been a lot of evidence accumulated since that time. There had been interesting measurements made in the Hawaii Islands for example; some of the rain falling in Hawaii, thousands of miles from the nearest source

of pollution, had been shown to be acid, and the only reasonable cause of that was long range transport of pollution perhaps from China or Japan or some other sources in Asia. He thought, therefore, there was really no doubt that long range transport was occuring worldwide, and that the UK was playing a part.

Turning to forecasting the transport of pollution, he said that this was a very interesting question and that a lot depended on precisely what type of pollution was under consideration. It had been suggested, for example, that if a reduction was required in the amount of industrial pollution landing in sensitive areas like southern Norway, where the lakes were being affected by acid rain and fish were suffering, then may be some sort of emission controls could be exercised. Economics came into the question and it might be just totally uneconomic to effect such controls, but from a scientific point of view it was conceivable. Fuels would have to be changed or emissions reduced ahead of time. It would be necessary to know that the air, starting say in six hours' time, would travel from the UK's industrial region to a sensitive area. There were numerical models in operation which would forecast the movement of depressions and anticyclones, etc., not only 12 but 24, 36 or 72 hours ahead. These models were improving all the time, but it required a pretty high degree of precision to be able to forecast the movement of pollution over the sort of ranges under discussion, about 1,000 km to the required degree of accuracy. Part of the problem was that, as he had indicated in his own presentation, the pollution was being carried not so much by the large scale winds aloft at about 2 or 3 km. above the ground, where the earth's friction did not play dominant role. On the contrary, a lot of such pollution was being carried in the lowest 1-2 km, where the earth's friction, the effect of sea breezes and mountains, all had a very important effect on the airflow. It was those effects which made the forecasting rather difficult. The Met. Office had estimated that if they wanted to forecast the movement of a plume from southern England to southern Norway, using a numerical forecast set at 24 hrs. ahead of time, then they would find it very difficult to be accurate to within about 200-300 km by the time they were considering possible depositions in Norway. If it was decided to reduce emissions in the event of a direct hit on Oslo for example, then the error might sometimes be 200 km to the right, sometimes 200 km to the left; that was the margin of uncertainty. That sort of error was a bit daunting, because the emissions might miss Norway altogether, and a lot of time and valuable low sulphur fuel would have been wasted. Taking all those problems

into account, he thought that scientifically, it was just about conceivable that as time went on, and forecasting techniques improved, some such early-warning/direct action measures might be possible. But whether it would be worth doing from an economic point of view was the big question.

Referring to Mr. Fuller's question about intermittent rain showers and the effect they had on washout, Dr. Smith said that certainly over mountainous areas such as southern Norway the washout of sulphate was perhaps the most important factor. There were in fact two main ways in which sulphur was deposited on an area. One was called dry deposition because it was the absorption of the gas in the atmosphere by the foliage and by the soils. The second was by the rainout process that had been mentioned. He explained that in mountainous areas, rainout tended to be the dominant process because as the air was being forced up over the mountains, it tended to produce intense rainfalls; typically over mountains as high as the Norwegian mountains, there would be four times the rainfall that would be experienced over the equivalent area of flat terrain, so that the amount of rainout in such circumstances was really quite large. Sometimes near a front, the whole air line would be lifted up at the frontal surfaces; as Jack Scott had explained, warm air would be lifted up over cold air and at a warm front rainfall tended to be rather uniform. It would not be completely uniform however; there might be variations of the amount of rain, particularly in mountainous areas, but almost all areas would be affected by some rain.

In other situations, there would be a different sort of process. For example there might be cold air from the north coming in over warmer air from more southern latitudes. In such a situation any air displaced upwards would soon find itself much warmer than the surrounding air - its environment - and because it was warmer it would be less dense, gravity would tend to accelerate it upwards. That would be just the situation in which large shower clouds could develop. When such large cumulus-type clouds build up, they tend to create a definite circulation. The whole of the sky stretching for a hundred miles would not be covered by that sort of cloud without breaks because as the warm air rose, air would converge to take its place at low level. Then convergances are so large they could not be met entirely by inflows hundreds of kilometres away but have to be met locally. The tendency is to have breaks between the individual cloud cells with down-flows in between the cumulus clouds to balance the

updraught within them; in the down-draughts there would be no cloud. Consequently intermittent precipitation and intermittent washout of sulphate would result.

SESSION 3

A VISUAL PRESENTATION OF THE EFFECTS OF WEATHER ON POLLUTION – Professor R.S. Scorer, Imperial College.
METEOROLOGY & AIR POLLUTION – Dr. D.J. Moore, CERL.

Mr. J.R. Teale (Institution of Gas Engineers), opening the discussion, congratulated the Conference Committee on the way in which the papers had complemented each other. He felt that the theme was an important aspect of atmospheric pollution. A major part of the UK complied with clean air requirements but, as had been implied that morning and afternoon, there were still problems associated with pollution being transferred or transported from a source to a remote location. As Donne had written "No man is an island unto himself". Scandinavians regretfully had to agree with that philosophy as, apparently, also had the Scots when they were being affected by red rain. In the area where he himself was working, the transfer of pollution was a matter of some concern. A local Environmental Health Officer had been rather worried about the pollution which was appearing in his area, which was not being emitted by any of the sources under his control. He had taken one or two plane flights to find out where all the pollution was coming from: it had turned out, to Mr. Teale's regret, that his own home town had been one of the offenders.

He also congratulated the authors for two extremely interesting and educational papers. He thought that Professor Scorer's slides had been admirable, and he praised Dr. Moore's diagrams; he hoped that the delegates had examined the diagrams on display in the lobby, which he thought were also extremely informative. In fact, he had found the diagrams in the hall more educational, or easier to understand than the ones in the published preprint of Dr. Moore's paper. After reading the preprints, and hearing the authors' presentations, especially those of that morning, he wondered whether everything about the effect of weather on pollution or how pollution is dispersed was really known. Quite a lot was known, but he wondered what futher research was going on. He asked whether information could be gleaned with regard to the traverse of pollution. He wondered whether the satellite readings that meteorologists were using could be applied to gaining information with regard to the transfer of pollution. If this could be done, he wondered who would supply the information. He had noticed that bouyancy had been mentioned in one of the papers as a factor which assisted in the dispersal of gases and as had been pointed out, it was especially important when there was no wind.

Considering the effect of the current preoccupation with fuel efficiency on the bouyancy factor, he assumed that the degree of bouyancy was determined by the temperature of the gases. In that case, someone striving to increase the efficiency of his plant would, in so doing, reduce the temperature of his flue gases. He asked what was considered to be the minimum temperature required to ensure the dispersal of the products of combustion.

Turning to low-level pollution, Mr. Teale said that he himself was a Mancunian, and used to think years ago that Manchester Town Hall and the Art Gallery were made of black stone. Only with the War, when shrapnel hit the buildings, had he realised that under the black there was a different colour and that for some reason or other the Town Hall and Art Gallery had turned black. To most Mancunians the Town Hall had always been a silhouette: it was never a building. It was only when the Town Hall had been cleaned that Mancunians had realised what an architectural beauty Manchester boasted. The blackening had been due at that time to low-level pollution. But most of the major buildings in Manchester were being cleaned, and he noticed that they were still getting dirty. That was not due to the burning of fuels on domestic grates, but due to pollution from cars. He had been most intrigued by the slides that Professor Scorer had shown of the bad old days of pollution. But seeing those slides had made him wonder why people had so blindly accepted those condition: yet they objected when Mr. Teale smoked his pipe!

<u>Cllr. D.R. King</u> (Middlesbrough Borough Council) asked whether vehicle exhaust fumes and other ground level pollutants were also affected by high-level emissions or prevented from dispersing, especially in areas of high density development.

<u>Cllr. J. Campbell</u> (Middlesbrough Borough Council) asked Dr. Moore to enlarge on the transport of pollution to Scandinavia, and also asked what was the greatest distance over which pollution was likely to be transported.

<u>Mr. A.J. Clarke</u> (CEGB) referred to remarks made about the evocative quality of many of Professor Scorer's slides; one of the

slides in particular had a personal evocative memory for him. It showed the effect of a power station in Hong Kong on the inhabitants of that town. Mr. Clarke explained that, in 1966, he and one of his colleagues from the Generating Board had been asked by the Government of Hong Kong about that particular situation.

The power station, even then, had been somewhat elderly, but vital to supplies in the colony. Just over the hill behind the power station there are a number of resettlement blocks, built to house the enormous influx of refugees in Hong Kong in the 'fifties and early 'sixties. They are ten-storey blocks of single room family apartments and each block houses as many as 10,000 individuals. The Hong Kong authorities had installed a sulphur dioxide gauge on the upper floors of one block. The pollution problem was particularly acute as the wind in Hong Kong blows in a monsoon regime, with a very steady easterly wind for six months of the year.

Mr. Clarke explained that he was referring to the situation not because of the weather; but because one peculiarity arose in the investigation which had a great deal to do with attitudes towards a risk to which individuals were subjected. A population of tens of thousands of people, was being exposed to severe pollution day by day; if he recalled correctly, the readings were of the order of 600 or 700 $\mu g/m^3$ as a monthly average, which was quite frightening. The fairly obvious short-term solution would have been to increase the height of the very short chimneys, but the power station was close to the runway of the Hong Kong's International Airport. International regulations on heights of buildings in the vicinity of airports did not allow the stacks to be any higher.

Mr. Clarke had pointed out in his report that what was really being considered was a balance of risk. On the one hand, there was the very small increase in risk of an aircraft loaded with people hitting the taller stack, (normally the planes came nowhere near the power station.) On the other hand, there was the certainty of subjecting a captive population to very high SO_2 concentrations day after day and year after year. It had been quite impossible to move the Civil Aviation authorities away from their established view; they had held their regulations to be absolutely sacred and no discussion of increasing stack height had been possible. He put the situation to delegates as an interesting view of attitudes to control. One factor had been regarded as flexible, the other as totally inflexible, but to him the

risks had not been at all comparable. In the end, the power station had changed to burning natural gas of very low sulphur content. In the course of time the generation had been transferred from that site to a new power station in another part of the colony, and so the problem had eventually been solved.

Mr. H. Dawson (Rolls-Royce) said that one of Professor Scorer's slides had shown a picture of aircraft condensation trails. He said that typically, in 1979, an aircraft at 25,000 ft putting out a fairly clean exhaust with a mass flow of probably about 2,000 lbs/air per second would form a condensation trail and depending on weather and other conditions they varied. Sometimes they stayed quite coherent, at other times they were visibly blown about by the wind, but on some other occasion they seemed to disperse and create a light haze on which other clouds seemed to form, and eventually quite significant shading would occur. He asked Professor Scorer how and why that happened, and whether it could be predicted, and finally whether it was considered to have any significant effect on the weather on a macroscopic scale.

Mr. I.W. Barker, (Sheffield Metropolitan District Council) said Professor Scorer had suggested, when showing a picture of plumes from the Consett Iron Company in Co. Durham, that by virtue of a happy accident of topography the emissions did not represent a serious pollution problem in Consett. Mr. Barker said that having himself a more than passing acquaintance with that town, he knew at first hand what the effects of that pollution really were, and in his opinion they constituted an affront to the community who had to endure them.

Professor Scorer had stated in Session 2 that, compared with nature's potential for pollution, man's efforts in that line were puny. That afternoon he had made the point that one of the formulae on which enforcement officers relied to assess the required height of chimneys, could be universally applied to the myriad disparate meteorological conditions which could be encountered. Mr. Barker wondered whether Professor Scorer's point was that the situation was so complex that there was no longer any point in trying to predict the behaviour of a plume from a stack of any given height; and that since man-made pollution was trivial compared with that of nature, there was

no point in even bothering. Mr. Barker thought, however, that Professor Scorer might be saying that judgements on required chimney heights should be made in the light of more empirical considerations.

Cllr. Mrs. E.M. Tomlinson (High Peak Borough Council) said that she was making a comment, not asking a question. She hoped that by the end of the following year Professor Scorer would be referring to the plumes of dark smoke from the kilns in the past tense. She reminded delegates that he had shown some kilns churning out lots of black smoke; she assured Professor Scorer that the smoke at Tunstead kilns had been eliminated by turning over to North Sea gas-firing and that the plumes from the kilns at Hindlow would be discontinued by the end of the following year because they were being replaced by Mertz kilns to be fired by North Sea gas. She felt it was most important to mention these factors and hoped Professor Scorer would take note accordingly. High Peak and Buxton were being promoted, quite rightly, as a tourist area, and did not want to be associated with a lot of dirt and black smoke. She paid tribute to the Quarrying and Lime Burning industry in the High Peak area; due to pressure from the local authorities and the public they were spending tremendous sums of money annually to improve the environment and they were doing so very willingly, after discussion with liaison groups set up by Alkali Inspectorate.

Mr. T.A. Dorling (Warren Spring Laboratory) said that the burden of Professor Scorer's paper seemed to be that the general public could detect pollution by their senses. He remarked that this was patently true but presented its own problems. Such subjective judgements resulted in the general public complaining about the odours which reached their noses, the chimney plumes which they could see which might be largely water vapour, the dust that fell upon them and their laundry and the black smoke which they saw coming out of the exhaust pipe of the diesel vehicle behind which they were stuck. There was a tendency to ignore the pollutants which they could not detect by their senses, e.g. CO, SO_2, possible carcinogens,etc. which in some cases were potentially more harmful. He made a plea for the recognition of the importance of instrumental air pollution monitoring by which objective measurements would produce the facts and would therefore contribute to providing

the information required to ensure that the public might be adequately protected. He asked whether Professor Scorer believed that much of the air pollution monitoring being carried out was a waste of time.

REPLY TO DISCUSSION

Professor R.S. Scorer expressed surprise that Mr. Dorling had drawn the conclusions he implied. Clearly some special emissions need to be monitored. The essential point was that most pollution was not so harmful that none of it could be emitted, and usually it could be detected by the senses before it became harmful so that the senses should be used for that case. Substances which were so poisonous that were dangerous in quantities that could not be detected by the senses were often accompanied by other pollutants which could be; for example CO was known to be present in car exhaust and this could always be detected by the nose if the CO were dangerous. Some substances however were so dangerous that they should not be emitted at all, or only under very special controlled conditions, and control by monitoring was quite inappropriate. Tall stacks were routinely used for nitric oxide emissions without environmental monitoring, but dioxin should never be emitted at all, and could not be treated by normal dilution.

Consequently it was important to monitor, or have sufficient knowledge of, emissions. It was quite unnecessary to monitor most ordinary emissions because they were known from appearance or from data about fuel used. A keen observer could soon understand when dilution mechanisms were working effectively, and when not. CO presented no problem because the public was not normally exposed to more than about a tenth of the concentrations produced by smoking and CO is not usually the major problem with smoking anyway.

Answering Mrs. Tomlinson, Professor Scorer said that he had not actually complained about the lime works at Hindlow but had used its visible plume to illustrate how pollution can be carried in eddies behind buildings. Although he was glad to hear that the operations there would soon be discontinued he reminded Mrs Tomlinson that High Peak Council had only two years previously tried to use "the cuts" as an excuse for not pursuing the objectives of the Clean Air Acts, and that it was only through the stern activities of some of the society's members on the Clean Air Council and the work of an individual councillor that the Minister had refused to give the council permission to revoke

recent smoke control orders.

Mr. Barker had declared the emissions of the Consett steel works to be an affront to the community. Whether that were so or not it was not the only pollution of the air. There were many other industrial plants on the low ground below and much objectionable domestic pollution in Castleside and Blackhill. Professor Scorer thought the affront might be mainly psychological, for people worried much more about what they could easily see, and often did not worry about what was more serious but less obvious. Highly concentrated whiffs smelt as a person walked down the road were more quickly forgotten than sources which remained visible but did no harm. We must be careful to direct our attention to what was most harmful. That was not an answer to Mr. Barker's question but it was desirable to avoid the wrong emphasis.

For example the black smoke from flare stacks had been widely objected to although it was usually very adequately diluted before reaching the ground. Great efforts, with steam injection had been expended to improve combustion, although the heat could not be used; but that often made the flare noisy which was objectionable at night - when, of course, the black smoke did not matter. Some power stations did soot-blowing only at night for visual reasons: the procedure improved the boiler efficiency and some staff thought that soot-blowing was done at night to give the night staff something to do, but it was only because it caused complaints by day. Professor Scorer said he was not trying to knock speakers from the floor but merely emphasising that such arguments needed to be clearly sorted out, and dogmatic statemetns often mislead people away from the real problem.

Mr. Dawson had asked about aircraft trails. Professor Scorer reminded him of the vastness of the atmosphere, as described by Mr. Scott. The trails appeared where the air was unsaturated for water but supersaturated for ice. This meant that in that air ice crystals would grow but water droplets would evaporate. All clouds had to start as water droplets, and although supercooled often took many minutes to freeze. If a trail cloud froze it would, in such circumstances, persist. Sometimes, with less water vapour present in the air, even trails frozen to ice crystals slowly evaporated, and could in the mean-time be spread out by wind shear into quite extensive clouds. Mr. Dawson had raised the question whether such artificial clouds had any affect. In Professor Scorer's opinion the

effect was not significant because clouds, altogether, had a very considerable stabilising effect on climate, and more cloud in one place merely meant less somewhere else. It was, in the opinion of many meteorologists, this property of clouds which had been the major cause of the rather even average world temperature around 10°C for 3½ thousand million years, in spite of ice ages which, according to some simple (but erroneous) models, should have frozen the whole ocean. There were some who attributed more of the explanation to the activities of life in controlling such important gases as CO_2 and O_3, but Professor Scorer favoured the theory that clouds were the most important because of their very quick response on a large scale to small changes such as diurnal variations.

Acknowledgements must be made to those who had provided the pictures which Professor Scorer had not taken himself. Among those was that of Hong Kong power station shown by Mr. Clarke. That had been taken by Dr. Gordon Bell, director of the observatory. Some of those pictures were now so well known as to have become almost public property.

Councillor King's question, whether high level sources could have any adverse effect on the effluents from low level ones, would best be answered by Dr. Moore, but Professor Scorer could not think of any immediately. Nor could he answer Mr. Teale's question about pipe smoking: he just hoped he enjoyed it if he had to do it.

Pollution from cars was one of the most pressing problems of the age. It would be alleviated within 30 years by a much reduced usage of cars due to fuel shortage and high costs. If synthetic fuels were used they would probably be pure hydrogen, from which the fumes were not noxious. But excessive water vapour might cause visibility problems in big cities. Professor Scorer's own "solution" was simply to make the running of cars more expensive and spread out the use of fuel over many more years, but he admitted that that was not a solution in the ordinary sense.

That led to the final issue raised - fuel efficiency. Combustion efficiency had been improved to the point where there was not much more to be done from the fuel economy view point. That meant using more power station waste heat, or more combined heat and power schemes which meant burning fuel in or close to cities where the heat would be mainly used. Effluents would therefore be cooler and nearer to dense populations, and that was a problem that deserved urgent attention.

Dr. D.J. Moore replying, said that as far as the effects of bouyancy on the rise of pollution were concerned, he thought the major consideration was to make sure that the plumes had positive bouyancy, in other words that the gases were lighter than the air. In the case of combustion products that meant that they had to be considerably more than 10 deg. C. warmer than the surrounding air because in fact they had a slightly higher density and ambient temperature because of the replacement of the oxygen in the air by the carbon dioxide. Therefore gases should be perhaps several tens of degrees C. above ambient temperature. There were practical difficulties associated with cooling becasue if gases were to be cooled below the acid dew-point, there would probably be problems of deposition of acid within the plant or within the stack which could cause deterioration of the plant. So there were practical problems, apart from air pollution, arising from saving the heat that went up the chimney. He also pointed out that in electricity generation, only about 5% of the total energy was represented by the dry flue gas loss; by far the greater loss, as Professor Scorer had said, was in the heat rejection by the condensing cooling system, so stack heat loss was a fairly small part of the total. There was also a wet flue gas loss due to the large amount of water vapour emitted via the stack. Typically, something like 60 grammes per kg. of the flue gas was water vapour; if the latent heat from that could be recovered, it would be roughly the same as the dry flue gas, and therein lay the problem.

In the recovery of dry heat, condensation would start because of the water vapour. It was fairly generally agreed that the rise of the plume was proportional to a fairly low power of the total heat emission, somewhere between 1/4 and 1/3 power, so if the total heat emission from the stack was reduced by a factor of 2, that would only represent a 20% reduction in the plume rise. Therefore, perhaps half the dry flue gas loss could be recovered, if corrosion problems were not encountered, but that would probably be something like the limit with present technology.

As far as the interaction with low-level plumes was concerned, he did not think there really was any interaction; the title of his paper was 'Meteorology and Air Pollution' and not as printed in the Conference Handbook. The printed title had been a little misleading as he had been talking about the relationships of the plumes to the weather situation, not the other way round. He supposed it was possible to imagine some weird situation where there might be some interaction, but in general felt that they would not affect low-level sources and he reminded delegates

that the major problem with vehicle emissions, particularly in street canyons, was that there was very little ventilation. There were models which made it possible to calculate the concentrations that could build up in street canyons; there were physical models as well as mathematical or theoretical models, so he thought that problem was being tackled fairly well. If pollution was emitted into a street canyon where there was little ventilation, fairly high concentrations of pollution would be built up and the amount or level would depend on the rate of emission and on how rapidly the air was being changed in the canyon, which depended on the geometry and the particular size for a given wind speed. Oxides of nitrogen from the vehicle emissions also contributed to the long-range transport problem, because although the pollution would be circulated in such canyons, most of it in fact would escape eventually; as he had explained in his talk, low-level pollution was not all deposited locally, although it could produce high ground level concentrations.

SESSION 4

GENERAL METHODS OF MEASUREMENT AND MONITORING - Dr. A.W.C. Keddie

ADVANCED METHODS OF MONITORING AND MEASUREMENT - Dr. R. Varey,
Mr. D. Green

Mr. N. Parkinson (Selby District Council) opening the discussion, said that bearing in mind Selby District Council's involvement in the measurement and the monitoring of particulate emissions, he was very pleased to have been asked to open the discussion on the two papers that had been presented on measurement and monitoring, which he thought had been very interesting. He thought it might be useful to delegates if he briefly explained the reasons for Selby's involvement in the monitoring and measurement of pariculate matter. He said that the Selby area was predominently agricultural in nature, but that on the south and south-west sides a large percentage of the nation's electrical energy was produced in three large power stations: Drax, Eggborough and Ferrybridge (the latter being situated on the boundary with West Yorkshire and Wakefield Metropolitan District Council). On the completion of Drax, approximately 20-25% of the nation's electricity would be produced in the Aire Valley. In practical terms, that meant that the three power stations, Drax, Eggborough and Ferrybridge, would burn approximately 20 million tons of coal per year, producing around 4 million tons of pulverised fuel ash which would be arrested and tipped on the nearby sites and some of it sold for other purposes. Even with a maximum precipitation efficiency of 99.3%, that group of power stations would be discharging approximately 500/600 tons of pulverised fuel ash into the atmosphere each week. Due to the 'high-stack' policy it would not all fall on the community of Selby. But there was increasing concern in the Selby area regarding the possible long-term cumulative effect those particulate emissions might have on the local community, quite apart from the gaseous emissions.

He asked Dr. Keddie two questions, first whether the differential lidar could be used for particulate monitoring, and secondly, whether there were any remote sensing techniques developed or being developed that would be suitable for particulate monitoring.

Staying with Dr. Keddie's paper, he said he had been particularly interested in Chapter 4, on Pages 12 and 13, dealing with the measurement of odours. He had been reassured to read Dr. Keddie's

conclusions that only a human observer could indicate that an odour was present, and indicate the intensity of that odour, because with a massive increase in the spreading of sewage sludge on agricultural land, it looked as though the Environmental Health Officer's nostrils were not going to be out of a job for some years to come. As his officers told complainants,"it might be effluent to you madam, but it's bread and butter to me." That was providing the officer could keep his olfactory sense. The previous day's theme had included the senses, and they had been mentioned again that day. Talking of the senses on the lighter side, he was reminded of a report he had read in a local evening paper - A woman arrested as a prostitute had claimed that she was too short-sighted to ply for trade. She was blind in one eye and vision in the other was blurred. She told the local magistrate "I can only see people if they're right on top of me."

In his opinion, SO_2 monitoring was pretty well complete, and to a large degree predictable, mainly due to the splendid work that had been carried out over many years by local authorities and the CEGB in conjunction with Warren Spring Laboratory. Because of that, he hoped that in the not too distant future, local authorities, small as well as large, along with industry if possible, would give far more attention to the monitoring of specific environmental problems, if necessary in some cases on a research basis. He strongly recommended to local authority representatives at the conference the use of Section 80 of the Control of Pollution Act. That was the section enabling local authorities to request details of emissions from industries within their area, so that the local authorities and the public could be made more aware of the levels of pollution within the environment in which they were living.

Turning to the paper of Dr. R.Varey and Mr. David Green, he said that it was quite obvious that the advanced methods of monitoring and measurement were going to be far more costly than the more conventional methods which local authorities had been using. The joint CEGB/Selby District Council survey would cost in excess of £60,000 at the end of the 5 year period, and that excluded any cost of equipment. Dr. Keddie had also drawn attention to the point of cost. Mr. Parkinson was pleased that a number of local authorities throughout the country were spending much more on monitoring the local environment, and relating that monitoring to specific problems. Section 79 of the Control of Pollution Act had given local authorities the power to spend money for that purpose, and it was under that heading that the Selby authority was contributing to the joint CEGB scheme. The survey

had shown what could be done jointly with industry in relation to monitoring, but having said that , he felt that Selby had been rather fortunate in that the CEGB, as industrialists, were extremely conscious of their statutory responsibility to reduce, as far as possible, their environmental impact on the local communities. Selby District Council had found the CEGB only too willing to co-operate on the exercise.

He said that, having considered the monitoring of specific air pollution problems, environmental health authorities ought also to examine the possibility of relating their findings to the effects, if any, on human health. There ought to be very early discussion with the district community physician and the medical officer for environmental health, prior to any intensive monitoring programme, so that consideration could be given to the possibility of bringing together medical as well as scientific data. He felt that the UK depended far too much on overseas standards. The UK's record in that direction was very poor, and he imagined that when arguing standards for future EEC Directives on pollution, the UK would find it difficult to substantiate many of its claims.

He asked Dr. Varey and Mr. Green four questions. First,in relation to lidar, he wanted to know whether the instruments could be used for the investigation of local problems as opposed to research programmes. Secondly, he asked how much study had been done by the CEGB in relation to particulate fallout concentrations at ground level. He wondered whether the Board were aware, for example, of the percentage of respirable fractions, together with the spread and distribution below 7 microns of say the 600 tons of PFA emitted weekly from the three stations he had referred to. Thirdly, with regard to the joint multi-element survey, he asked whether Mr. Green could give an explanation for the variance in levels in different areas, bearing in mind the similarity of rural surroundings and the rural monitoring sites. Finally, he asked whether any work had been done on, or whether there was any evidence of, low-level contributions to particulate matter. He was thinking there of domestic chimneys.

Dr. W.R. Bulcraig (Individual Member) said he was interested in the analyses of solid pariculate matter from measuring sites in the Selby area. He said that data of that type were very sparse, and, for example, in Merseyside data on atmospheric dust had not been determined since the survey by Dr. Stocks

in 1956, and since then there had been significant changes in fuel pattern, e.g. from coal to oil and gas.

To consider the analyses of dust relative to the power station activity it was necessary to know the analysis of the ash of the coal used. The efficiency of the precipitators meant that there was unlikely to be a significant effect at ground level and a careful comparison of the composition of the dust collected and the original ash was required. Two elements which were normally present in the coal ash and which might be used were titanium and manganese.

He asked what was the analysis of the coal ash from typical coals used in the local power stations, and which elements were considered suitable as tracers.

He wondered whether analyses of that type could be used to try to identify long range transport of gases from power stations, rather than sulphur dioxide.

He asked whether isotopic ratios of commoner elements had been used to try to distinguish between dust from power stations which had been laid down in the carboniferous era and dust from the present soil.

Finally, he asked whether figures for titanium were available for tables 2 and 3, and whether these could be included in the final text.

Mr. P. Sutton, (Esso Petroleum Co. Ltd.) noted that Dr. Keddie relied on panels of a small number of people to define odour thresholds and dilution ratios. He asked whether Dr. Keddie had any experience of the use of panels, or members of the public, to identify odourous components by verbal description or by comparison.

Mr. Sutton said that Mr. Green had shown photographs of samplers for suspended particulates and had mentioned specifically that one objective was to sample for respirable dust. He said that the kinetics of sampling were important if representative or specific samples were to be taken. If respirable dust was wanted, he wondered whether the authors had considered the use of a 'standard nose', utilising sample bellows simulating a 'standard lung', so that specifically those particles which would be taken by ~~up~~ by human respiration would be sampled.

Cllr. J.M. Bramley (Selby District Council) said that as he lived in Cliffe, he was referring particularly to Page 14 of the Varey/ Green paper; he saw from the results of the Cliffe directional, that three times as much coal ash was being dropped there than on anywhere else in the district, although he did not think that there would be many complaints about it. He was more concerned with the lead and the zinc, the levels of which , in Cliffe , as could be seen from the scale, were three times as much as in most of the other areas. He asked whether the speakers still considered those levels not to be injurious to health.

Cllr. J.C. Blewitt (South Oxford District Council) said that he supported the outline comments made by Mr. Parkinson from Selby, with reference to the Control of Pollution Act, Sects 79 and 80, regarding local industries' emissions and measurements of such. His point concerned the large new power stations being used; with coal-firing, the waste residue called 'fly-ash' was a cause for concern.

He said that although fine and coarse particles could be detected, and very large amounts were accounted for,it was noticeable that micro-particles of such fine type could cause and were causing irritations to the health of those who suffered from chest, lung, asthmatic and bronchitic ailments, as they upset the progress of relief. On the other hand, modern paint shops for the motor industry could also cause great concern to the residents adjacent to such sites. In Oxford, the last paint shop in the area had caused mistrust, bad feeling and misgivings, because the original project had been passed without full realization of the problems likely to arise,which were outside the usual understanding of pollution problems.

A further new paint shop was being envisaged, which would affect many more of the local community of two adjacent district councils. He urged that closer liaison and dialogue with co-ordination would be undertaken, and that such pollution problems likely to cause distress to the local community should be re-arranged so that there could be a solid base to work upon, to enlighten the future structure of paint processes and means of washing, filtering, drawing of such paint flakes and micro particles, etc. Whilst the shell of that plant went up on site 'if full clearance is given', all possible known pollutants should be assessed and graphed, and monitoring theories with computer data on types and nature of paint processes to be used and nature of paint molecules sould be included.

He said that if the two district councils were to have the trust and confidence of their Environmental Health Officers, participated through the trust and confidence of District Cllrs and the community, then they had to ensure that the experts within the NSCA could provide the technology, when called upon to do so.

His other comments were directed to the NSCA. He said that if the ban on local authorities' spending was not varied, then support to keep the Society in business was in a great danger. He thought that the 1979 Conference had been miserably supported compared with the support and attendances at the previous 12 conferences.

He felt that the quality and participation of the local council representatives had been very disappointing. He said that with the loss of the older, experienced councillors,and many of the old public health officers (now environmental health officers) who would be soon be retiring, the future could possibly be bleak. He thought it was important to increase more involvement and support, better means and presentation of the Clean Air Society; it was necessary to build up a joint district council basis, providing facilities of equipment and techniques so that the closer links of co-ordination and working understanding could be established .

He thought it was possible that the financial burden facing the environmental officers and their departments could be better supported by de-centralising government grants to area bodies, so that with their known community services financial estimates, the environmental health service would not be diluted, or there would be a step backwards which could never be reverted, if existing trends were enforced on a political basis.

He said that the UK should not change its standards to conform with EEC directives, rather, the other countries should conform to UK standards which were proven and accepted. He felt that the UK's hygiene standards on sewerage, rivers and waterways, vegetation life, together with protection measures for wildlife in the countryside, should be fully accepted by the EEC.

He said that the UK's future energy programme of using more coal and nuclear power was very understandable but to get the full support of the Society, more public participation through their Councillors, councils and officers, with the proper involvement of industry, the future pollution control act must be got across to the public in understandable language.

Referring to the future hazards and possibilities of breakdowns or leakages, he said that there were possibilities of containing such accidents with effective pattern controls, and that those were the sort of health criteria policies the public wanted to see implemented and wanted to know about so that they could be certain that their health and environment were being really protected and understood by those responsible for the future of mankind.

He summed up by saying that he had tried to express the public's attitude to pollution control policies. He said that no one should underestimate the power of the people on energy policy, as they were the ones who would be paying the bill, in money, health, life and death.

Mr. P.M. Jones (Leeds City Council) said that, bearing in mind Mr. Parkinson's questions concerning the application of advanced analysis to local problems, he was interested in possible dust emission from a lead works. He wanted to know (returning to the overall theme of the conference) whether Mr. Green had noticed large seasonal variations due to general weather conditions in the dust-borne metal elements levels he had collected.

Mr. A.G. Shankster (Stockton-on-Tees Borough Council) said that odour limit values were quoted as being absolute or 100 percent and that might lead to discrepancies - e.g. perchloroethylene TLV = 100 ppm, odour threshold given by a company producing perchloroethylene = 50 ppm, odour threshold given by a company producing sampling equipment = 5 ppm. He asked whether it was possible to provide a data guide to odour limit values. Secondly he asked what was the cost of lidar and correlation spectrometry equipment.

Referring to Mr. Green's statement that he was sampling respirable dust less than 7 ug, he said that a standard of 15 μg was being considered in the United States, whereas the size of particle capable of entering the lungs was about 2 μg He asked for Mr. Green's comments. Finally he said that he supported Mr. Parkinson's plea for local authorities to undertake sampling wherever possible.

Mr. J. Norton (Leeds City Council) asked whether the results of analysis from the BSS deposit gauge and the ISO deposit gauge had shown any specific relationship which could be

quantified (and used for interpretation of the results of the alternative gauge).

Dr. J.M. Richards (Individual Member) asked how weighted wind roses were calculated or how should they be calculated. He said that the polluted air which reached the sampler spent various times at various heights in the atmosphere. Wind speed and direction, stability and turbulent intensity (one or more of those) frequently varied with height and might also vary appreciably with time and with position in the horizontal, as had been explained.

To make the idea of a 'weighted wind rose' relevant, it would in general be necessary to use some rather sophisticated 3 dimensional trajectory method requiring simultaneous data from the various levels. He wondered whether such methods had in fact been employed.

Mr. Robert Felton (National Physical Laboratory) took the opportunity to remind the delegates that the National Physical Laboratory was developing a pollution programme. It was in the process of developing a series of gas standards, different from the absorption spectroscopy lidar system, very similar to the CEGB system, with a long path sensing system using infra-red radiation rather than the ultraviolet. He felt he could make several points concerned with advanced laser remote sensing systems which would be of interest to delegates.

First, that while the CEGB system had shown their DIAL truck trawling along in front underneath plinths, the DIAL system was potentially capable of producing a pollution map of a local area, and he wondered whether Dr. Varey would comment on and explain a little more about them. He wondered whether the local map was sufficient in itself, and whether sensors would provide unnecessary additional data. As for odorous materials he would also consider long path sensors for operating infra-red regional spectrum; they had the advantage of possibly being able to be operated on site, rather than in central laboratory facilities, with the potential for being technically straightforward. He asked Dr. Keddie to comment on that point.

He had other comments on other applications of tunable laser

systems. He referred to Mr. Parkinson's question and said that DIAL system in principle could cover the particle distribution of the plumes, but that practically the problem was very difficult; there was the scattering of light, depending in part on its shape, size, distribution and then on orientation with respect to the beam. Experimentally multiwavelength lidar systems would have to be used and that would increase costs. The lidar systems in use at that time involved choosing something like five or six wavelengths to get a believable figure. These facilities were obviously too expensive and too sophisticated for local authorities individually to utilise.

Mr. R.G. Webb (Cheltenham BC) wondered how much longer Dr. Keddie envisaged the national air pollution monitoring scheme continuing. The National Survey had been going for over 20 years and he wondered whether sufficient information on smoke and SO_2 had been obtained, and for how much longer Dr. Keddie envisaged that the Survey would continue in the same form. The apparatus, the volumetric filter which measured just the smoke and sulphur dioxide, was very simple, and he asked whether it should continue to be used, or whether Dr. Keddie had considered the use of the high volume millipore filtering apparatus. That had been used in the Avon, Gloucestershire and Somerset area for a programme of monitoring heavy metals. It had the advantage that it could be run for one month before the filter had to be changed, and it also had the facility of being able to monitor a wide range of heavy metals.

Mr. W.J. Heron (Brighton BC) said that the CEGB were spending a great deal of money monitoring the amounts of pollution that their power stations were emitting, Warren Spring spent a lot of money also monitoring particular problems in Great Britain. He wanted to know just what was the balance between monitoring and finding the solutions. He lived in an area affected by the Brighton B Power station. He knew that local residents were very concerned about the amount of pollution coming from that small power station. He did not think that there was a hazard to health involved; he thought there was more concern about the damage to the amenities of the area, the quality of the environment. Every now and again, perhaps because of the local coastal weather situation, the dust from the power station was deposited, certainly in the area in which he was living, and he said it was quite annoying to find his own patio covered with dust.

In his work for Brighton Borough Council he had had a lot of problems with odours, from a particular dyeing plant. The problem was well-known to exist. 100 people were able to tell him that the smell was there, but when they had consulted Warren Spring there had seemed to be a lack of information on an effective way to getting rid of the smell. They had been told to try incineration, had been quoted catalytic incineration, and had been put in touch with various firms, but nobody had seemed to be able to guarantee a solution to the problem. Therefore, he wanted to ask what was the balance between monitoring and researching solutions to such problems, and who decided what that balance should be.

Cllr. J.R.P. Evans, (Rhymney Valley District Council) commented in his opening remarks on the ever-increasing sophistication both in terms of equipment and techniques which was a feature of pollution control monitoring. He also noted that hand in hand with increasing sophistication came an increase in costs, both in terms of capital expenditure for major items of equipment and in terms of revenue expenditure for running and maintenance costs and for the salaries of employees. He reinforced the point made earlier, that it would be false economics to spend money on sophisticated equipment and then employ an unskilled technician (on a low salary) to operate - or possible ruin - very costly equipment.

Having touched upon finance he then considered the local government spending restrictions which were being enforced as actual expenditure cuts by the government, in all aspects of local government spending. He made the point that pollution monitoring and control, whilst very worthy and of undoubted high priority, was but one part of a very extensive and costly programme of local government spending on high priority projects. Cllr. Evans called upon the present Minister of the Environment to recognise the tremendous contribution which pollution monitoring and control had - through no small effort on the part of the Society - made to the quality of life in general and the continuing impact for the general good it could and would make if finance was not a very real constraint.

He then went on to consider what would be the likely consequences of failure by the Minister to recognise the value of the work being undertaken by local authorities and other bodies with the active support and encouragement of the National Society for Clean Air in the field of pollution monitoring and control. The first likely casualty would be 'on-going' projects designed

to enhance and complement the National Surveys (if indeed the National Surveys themselves survived). Thus data gaps would be become more and more likely, disguising or even distorting trends which could have very serious implications especially in respect of such monitoring work as the heavy metals survey.

Cllr. Evans thought that in the short term, it would be unlikely that there would be a return to the conditions which had given rise to the London smog incident mentioned by Mr. J. Scott in his paper, and there would be little impact initially on the 'call-out' or specific complaints service offered by the local authorities, but he thought that both the medium and longer term prospects were bleak. As priorities became more and more acute so less and less finance could be directed towards pollution monitoring and control. Thus would be set in train a possibly irreversible trend which would effectively negate the magnificent work of the National Society for Clean Air, together with the local authorities and nationalised and private industry, over the past 50 years or so.

Cllr. Evans then suggested that the National Society for Clean Air was the appropriate body to act as an informed and expert pressure group which could and indeed should lobby the Minister for the Environment for sufficient finance and capital equipment grants for modern pollution monitoring and control equipment, appropriate to the needs of local authorities. He stated that such finance should not be apportioned against local government expenditure, neither global nor particular for any region or authority, but should come from a totally separate fund. He also stated that the local authorities themselves, guided by their own expert advisers, should also determine their needs - not some faceless junior clerk in Whitehall with no specific knowledge, making purely arbitary decisions, the consequences of which would neither affect or bother him unduly.

Cllr. Evans concluded by stating that the local government expenditure cuts, which were totally unjustified and uncalled for by the British electorate, could seriously prejudice the next 50 years' work by local authorities and others in trying to build an environment which all could enjoy, which would not be detrimental to our citizens' health, young and old alike, and which would be a lasting heritage and worthy inheritance for our children and future generations in years to come. We should remember the world is not ours, we only hold it in trust for the future.

AUTHORS REPLIES

<u>Dr. A.W.C. Keddie</u> replied first to some of the more specific technical questions. Mr. Parkinson had asked if differential lidar could be used for particulate measurements. Dr. Keddie felt sure the Dr. Varey would also wish to reply to the question, but his own understanding of the situation was that the answer was yes. However, it was most unlikely that chemical characterisation could be obtained at the same time, certainly if one was thinking in terms of tunable systems similar to those used for gases. Dr. Keddie said that as a readily useable technique for routine day-to-day monitoring, differential lidar was still a long way off.

Turning to Mr. Sutton's point about particulate sampling and the design of sampling heads, Dr. Keddie said that the whole question of the design of the sampling head, so that a representative sample could be extracted from the atmosphere, was most important. He explained that there was a programme of work going on in Warren Spring Laboratory to look at various designs of sampling heads in wind tunnels. This entailed injecting into the tunnel different sized particles, and looking at the efficiency of 'catch' at different wind speeds. This work also covered deposit gauges, including the BS gauge and the proposed ISO gauge, to which Mr. Norton of Leeds had referred. From this type of work he thought that it would be possible to characterise the actual performances of different sampling heads.

The question of having a standard nose or standard head had been raised. Dr. Keddie said that this had been looked at by experts in the Occupational Exposure field, but he was not at all convinced of the necessity, or the appropriateness, of a standard head for sampling in the ambient atmosphere, particularly in the context of routine monitoring. It could be the thing to do in providing an absolute standard but with routine monitoring, what was required was a reliable and relatively cheap sampler <u>with known characteristics</u>. Nevertheless, quantifying the characteristics was extremely complicated because, as had been quite rightly pointed out, whenever an object (sampler) is put into an air stream it had an immediate aerodynamic effect on the flow features of the stream and on the particle kinetics. The effects are unique to each design of sampler and therefore it is very difficult to make a direct comparison of one with another. But the problem is receiving considerable attention, not only in the UK but also abroad, because there seemed to be little doubt that

during the next 20 years particulates would be a major air pollution topic.

Commenting that there had been a number of questions on odours, Dr. Keddie turned first to the one which related to the range of odour thresholds that he had quoted, primarily to illustrate the very low concentrations of thresholds. He said that part of the difficulty lay in the fact that there were different methods of determining detection thresholds. He explained that there was an American syringe method, where the odour was injected into the nose and was subject to an inadvertant dilution in the nose, which tended to lead to very high odour thresholds compared to those obtained by the dynamic dilution system used by Warren Spring Laboratory and which was not subject to that type of error. What was required , without doubt, was an acceptable and consistent way of determining odour thresholds. Dr. Keddie had been asked whether WSL could provide guidance or a guidance note on odour thresholds. He said that in principle it could be done and WSL had determined the thresholds of a few substances. However, the effort involved in covering the whole range of possible compounds would be very large and one would need to assess the demand for such guidance before embarking on a programme of this sort. In the event it would be necessary to be selective, taking on board only those compounds which were believed to be of greatest importance. On the question of scales he agreed that quoting odours in terms of a linear scale was in some respects a nonsense, in that order of magnitude changes in concentration produced only small changes in intensity. This behaviour could be fairly well represented by a power law but a further complication was introduced by the fact that there were significant differences in the value of the exponent depending on the type of odour. This meant that some odours were much more persistent than others, which tended to complicate the issue. Nevertheless, there was again room for improvement in terms of systematising the whole approach to the quantification and presentation of information on odours.

The other aspect of odours which had been raised was the question of chemical composition and how this might be related to what the panel was actually smelling. This had been tackled at Warren Spring Laboratory, using gas chromatography and ancillary techniques to identify the compounds while at the same time having panels of observers sniffing to identify the characteristics of the smell. This had helped and had clarified some points; but the work had also pointed out the complexities of trying to use analytical techniques to quantify an odour or even simply to

determine whether or not an odour was present. An odorous sample, whether it was from actual process gases before or after the abatement equipment, or in the ambient atmosphere, was in fact normally a very complex mixture of compounds. In some cases the compounds had an additive effect, and in other cases they cancelled each other out. For example, in the case of one gas stream containing H_2S and CS_2 the odour became very much worse when some of the H_2S was removed. He did not see any way of coping with complications of this sort in the foreseable future, except for specific relatively simple cases. The above points also related to the question which had been asked by Mr. Felton of NPL. These problems in characterising odours chemically would simply be carried through to long path sensing techniques and Dr. Keddie doubted if infra-red techniques could cope with a wide a range of compounds.

Mr. Heron had raised a question on the type of advice that could be given on odour control in relation to a situation in Brighton. Warren Spring Laboratory had apparently said that for the specific problem either straight incineration or catalytic incineration would be appropriate. Dr. Keddie said that, unfortunately, complete elimination of nuisance from odours could seldom be guaranteed at an acceptable cost, a major problem associated with the abatement of odours which arose primarily from the fact that they could be detected at extremely low concentrations, for very short periods of time. What could be guaranteed was that the nuisance could be reduced. The most efficient and effective way of removing odours was to incinerate them; this was fine with a highly concentrated low volume flow odorous stream but it was in most cases prohibitively expensive for large volumes of gases containing low concentrations of odorous species. In these cases one had no alternative but to resort to other, generally less effective, techniques such as chemical absorption.

Turning to the question of monitoring, Dr. Keddie said that the National Survey in its present form had probably fulfilled its useful purpose. The future of the Survey was currently being examined jointly by WSL and the Department of the Environment to determine, primarily from a national point of view, what was the best way forward in terms of technical requirements and value for money while at the same time ensuring that local authorities had some guidance on how best to allocate their resources to activities which would come outside the co-ordinated survey and which would be more concerned with local issues. He said that it was not his place, nor was it the time, to pre-empt the outcome of the discussions which were currently taking

place. However, speaking from a personal and from a technical point of view, there was no doubt that the time had come to carry out a critical review, not only from a national standpoint but also from a local one. He reminded delegates that concentrations of smoke were only a fraction of what they had been 25 years ago, and sulphur dioxide concentrations were also very much less. Furthermore, a great deal had been learned about the distribution and origin of pollutants from the National Survey, and other surveys, and, despite what Professor Scorer had said the previous day, our predictive (dispersion modelling) capabilities were much better than they had been 20 years before..

The balance of expenditure between monitoring, emission measurements, modelling and abatement should be examined in the light of current knowledge and requirements but he could not say at the time what the correct balance was; there was still a great deal of work to be done to determine policies for the future. Monitoring did play an essential part in deciding on the optimum way of spending money on pollution control. It was simply not possible to completely eliminate all emissions into the atmosphere; monitoring would continue to be used to decide on how best to invest expenditure.

Dr. R. Varey, replying, referred to the question about using differential lidar systems to measure particulates,and explained that it was difficult. The problem was that firing a laser into the atmosphere produced only a pulse of backscattered radiation; the amplitude was measured, and deductions had to be based on that. Many factors contributed to the amplitude of that signal, one of which was the density of particulates, but the shape and size of the particulates changed the amplitude of that signal; if there was water vapour in the atmosphere that caused a backscatter signal as well, molecules also contributed to the backscatter signal, and intervening gases such as SO_2 absorbed some of the signal. That was how the differential lidar system worked, and unscrambling the information received was not easy.

However, it could be used in certain circumstances and CERL were mounting a programme to look at the dispersion of particulates from a power station stack to see how different it was to the dispersion of the gaseous components. They were looking to see the way in which the particulates fell out of the plume. Lidar would probably work for that; it might be semi-quantitative but he thought it would probably give fairly useful information. Lidar systems had been used to look at particulate size distri-

butions in the atmosphere, as had been mentioned earlier. To do that it was necessary to use lasers of different frequencies, as was done with differential lidar, but it was necessary to have the wavelengths rather more widely separated than was done with differential lidar. Progress had been made in this field. He knew of several systems: two in particular, in which four laser wavelengths were used and some information was being obtained on particle size distributions over ranges out to several kilometers. The answers were sometimes ambiguous but it was a step in the right direction.

One thing which he believed could not be done with lasers in the atmosphere was to determine the composition of particulates remotely. The only way that could be done was to actually get up into the air, taking samples, bringing them back to the ground, and analysing them there. CERL were involved in that to some extent; they were flying samplers in real aeroplanes, and would be flying them in the model aeroplanes, samplers which used filter papers to collect particulates, which were then analysed in the normal way. They would also be flying miniaturised laser systems in model aeroplanes to do size distributions actually up in the air, in situ, and they were also developing a cryogenic system of sampling which they hoped would help to maintain the samples in the same chemical composition they had been in when the samples had been taken. When a sample was taken up in the atmosphere, particularly of aerosols or water droplets, by the time it was analysed on the ground, all sorts of reactions could have taken place, which rather confused the picture of what was actually happening in the air.

Speaking of local problems as opposed to research, he said that a good deal of that work was concerned with local problems. Every time they took measurements anywhere, it was a local situation, and so most of their measurements were relevant to local problems. He certainly thought that both the systems he had mentioned that morning, correlation spectrometers coupled with their ground level sensors, and differential lidar, were useful, as he hoped he had shown. They were useful in identifying and separating different components of pollution at a particular point. They helped to sort out which plumes came from where. That was particularly important with differential lidar because with height, the wind direction often changed, with on occasion quite severe windshear. If it was not possible to get spatial resolution, vertical resolution, in the measurements of plumes then it was very difficult to disentangle the complicated situations when there was windshear, when

emissions did not come to the ground where they were expected. Therefore he believed that correlation spectrometers and differential lidar had a role to play in local problems. He thought it was a little unlikely that they could ever be used on a routine basis, 24-hour averaging etc., because the instruments had not reached the stage where they could be left unattended, and they were fairly man-power intensive.

There were two other situations in which he thought that sort of apparatus would be useful. One was when there was dispersion in complicated topographic situations, such as hills and mountains. In that situation, it was very difficult to model theoretically; measurements had to taken and differential lidar and correlation spectroscopy were very useful in that respect. On a rather smaller scale, where there were complicated flow patterns around buildings, he thought that lidar had a role to play in measuring what was happening to air flows.

Turning to the advantage of mobile systems, and why they had been developed in the first place, he said that the answer lay in the rate at which they acquired data. The rate was very much higher than that from a fixed network. With a fixed network, any particular component of it was probably being used less than 10% of the time.

On the question of cost, he said that a correlation spectrometer was about £20,000(1979 price). But that was not the end of the story; with it some sort of navigation system was necessary for mobile sampling - that could be pretty cheap, looking at a mile-ometer and using an ordoance survey map, but navigating that way meant that the data had to be plotted by hand on return, and as data was acquired pretty rapidly, that was a time-consuming process. It was preferable to invest in some sort of micro-processor system to log the data and plot it afterwards. That he guessed, could range from perhaps £10,000 upwards, and there was also the cost of a lorry for transport to be considered. The total differential lidar system was about £100,000, comprising the laser: £20,000; computer: £20,000; lorry: £20,000; optical system probably another £20,000, totalling in the end for a fully mobile system around £100,000. That was small compared with costs of desulphurisation, but nevertheless quite a lot of money.

Dr. Richards had asked about wind roses and untangling the trajectories to find out where the particulates came from. Dr. Varey said that it was very difficult and complicated but that, as he had explained, differential lidar might be useful in

that respect. Robert Felton had asked a variety of questions and he thought a private discussion might be useful but he said that these systems were very useful for doing local surveys and he thought that they could play a very important role in producing pollution maps of local areas.

Mr. D. Green, replying, answered Mr. Parkinson's question first. He explained that the figures on the diagram had been calculated, but he felt that the actual measurements tended to agree with them. Basically he thought it was best to look at the rate figures at the bottom. Those were the total dust depositions around the 2000 MW power station with a 250 m. stack; maximum annual levels were of the order of 0.5 mg/m^2 per day. In fact, it was believed that the maximum figures deposited under normal conditions were up to 10 times that figure; those figures were to be compared with the typical range of values of 50-100 mg/m^2 per day on the rural countryside. Levels around Drax power station had been measured over the last 5 years on a series of National Survey gauges. It had been found basically that the sites affected by Drax, down-wind of the power station , gave a mean figure of 67 mg/m^2 per day, and those unaffected by Drax give 68 mg/m^2 per day. He was not suggesting that Drax actually cleaned up the atmosphere, but he was saying that the variability of results was such that it was very difficult to measure the contribution of the power station by deposition methods.

He had been asked what was the percentage of respirable dust in the total fraction of dust that was being emitted. He explained that that was a very variable factor but he believed that it was greater than 40% and that probably between 50 and 90% of the material emitted was respirable depending on the definition of respirable dust; but one notable feature was that that figure represented the total dust deposited and the respirable dust did not actually start to peak until between 7 and 10 kilometers away from the station, and then the levels were significantly lower. Talking in terms of the total amount of deposited dust, then the figure would be somewhere around the 10 mg/m^2 per day.

On the question concerning low level contributions to sources, he thought that very little could be said at that time, except that if the data for Selby and the surrounding countryside were examined, it could be assumed that most of the respirable particulates measured in the Selby area were in fact from low level sources. The levels were significantly higher in Selby than in

the rural countryside, so it could be concluded that the percentage of respirable material from local sources was high by comparison.

Turning to the question from Mr. Sutton, he said that he had not perhaps made it clear in his commentary on the slides that it had been the inlet to the sampler, and not the upturn funnels, that had been shown. It might well be asked why that type of sampler was being used. First of all, Harwell had built up a good data bank over the years for that type of sampler; starting the survey with a new type of equipment would have meant having no data for comparison; at least they would be able to compare their results with others in the British Isles. The second point was that sampler had been wind-tunnel validated, in the sense that they knew exactly how it performed, for a variety of sizes of particles. If more information was required, he suggested that subject could be followed by looking up the reference given in his paper. Many other types of samplers had been considered before that particular one had been selected, including the ones which had been used in the Bristol area, which had a number of significant advantages, for example that no-one could see tham and therefore there was very little vandalising of them. But the data bank had been the most important factor.

With regard to the British Standard nose, he thought that Dr. Keddie had already covered that reasonably well, but he added that basically the British Standard nose was very directional and he did not know how it could ever be possible to get it to sample properly out in the countryside.

Referring to Dr. Bulcraig's point that the ash in coal was basically derived from the soil, Mr. Green agreed that that was partly true, but said that in addition some of the coal came from vegetation, which having the ability actually to take up trace elements and concentrate them, gave rise to a concentration mechanism. In addition to that, once the fuel was burned, there was a volatilisation condensation mechanism taking place. Because the surface area to mass of small particles was greater than that of larger ones there tended to be a high concentration of those elements which were volatile and would condense again on to the smaller particles. So there was a difference between materials that had been burned and straightforward soil which was detectable, but with regard to being able to see the effect in Norway by looking at elements that had been concentrated or particular ones, there was perhaps the problem, which he had mentioned briefly in his talk, that all over

the northern hemisphere there was a very similar distribution of trace elements, and nothing in particular stood out as being a good tracer. Perhaps what was really being seen was the effects of man's activities which had got very high into the atmosphere and were slowly being deposited, so that to look for a single element or a group of elements, which would enable long range transport to be detectd, was not really possible.

SESSION 5

SIR DEREK EZRA'S PRESIDENTIAL ADDRESS TO NATIONAL SOCIETY FOR CLEAN AIR <u>Reconciliation of Future Energy Needs with Improving Environmental Standards</u>

I am delighted and honoured to have been invited here and also to have been invited to take over as President of this important Society. When Brian Flowers asked me if I would do it, I had several hesitations;I had one or two other little things to attend to, secondly I felt that after his illustrious lead he really needed to go for a much more important figure than myself. However, he did persuade me and I am very glad that I accepted because the Society's work is an aspect of life which has been a great concern to me and to the industry that I represent and have been involved in for over 30 years.

I am glad that the Chairman paid a tribute to the mining industry; it is not often that we receive them! The industry has really taken the question of clean air to heart. Historically, the dirty air of Britain was due to the industrial revolution, to the discovery that coal could be used for steam raising and other purposes, so that Britain became industrialised faster than other nations. But of course a terrific social penalty was paid for that, and we in the coal industry of today are delighted to be able to put that right, by progressively getting rid of the remmants of the coal industry of the past in the form of the pit heaps, and also by making sure that the way in which we operate, now and in the future, is as effective as possible.

I feel that it is the duty of a President, who, fortunately, I have been assured, has limited duties, at least to give his opinion, for what it is worth, of what the Society should be doing. And I have no doubt myself as to what its prime task should now be because we are living in a world in which two factors are of primary importance. One is energy and the other is the environment, and the great problem which we now face is the reconciliation of those two requirements: the requirement for an adequate and continuous supply of energy on the one hand and the safeguarding of a satisfactory environment on the other. That is one of the most important social problems that we face in the years ahead. And so I would like to feel that I am associated with a body which is going to address itself, both in its private discussions and in its public stance, to this problem.

How do we reconcile these two issues, the need to have the energy required to maintain and indeed improve our standard of living, that of an industrialised nation, and at the same time to give us a satisfactory environment which is an overriding issue of our times? I would like to talk a bit about this issue, starting with the energy situation as I see it, because of course that is a problem with which I personally am very much concerned.

We are now going through a very difficult phase in relation to energy. We have been through three stages since the end of the last world war. There was the period of post war reconstruction, when energy was in very great demand and coal was the dominant form of energy. Around about 1957 there was a complete change when the large amount of oil from the Middle East came onto the market, and the general view at that period, which lasted for some 15 years or so, was that we would be running more and more of our enterprises and our living systems on the basis of the large quantities of low priced oil coming on to the market. That stage coincided with a massive period of economic growth such as the recorded world has never known before. But of course that was all brought to an end very suddenly with the decision of the oil-producing countries in October 1973 to increase the price of their products three fold and eventually four, five and six fold compared with previous prices.

We are now living in a very uncertain energy period. In my opinion, the one aspect which we must consider above all others in looking at this question of energy and the environment is that the worst impact energy could have on the living environment and on the living standards of people, is to be in short supply. That overrides every other consideration. We have seen the crisis that was created by a marginal shortage in the latter part of 1973 and, only earlier this year, we have seen another crisis, with the petrol queues in California and many other countries; even in Britain there was great concern. So we have got to be realistic: the one environmental aspect of energy which we must avoid at virtually all costs, unless we want to sacrifice our standards of living and our social structures and our way of life, is shortage, and so the first requirement is to make absolutely sure that we have an adequacy of energy supplies.

We in Britain are, of course, very fortunate, because we have the benefits of the North Sea. Indeed if it were not for the

oil and the gas from the North Sea, our present position in the world would be vastly weaker than it is. The recent figures on the balance of payments, for the month of September, have shown that we were roughly in balance in financial terms in our world operations, and that balance was entirely due to the benefits that we were getting from North Sea oil; in all other respects our position is weakening. So this question of self-sufficiency in energy for Britain is becoming a much more important one than simply of having the energy we need. It is becoming a question, nationally, of being able to hold our position with other countries. We do know that the availability of energy in the North Sea is limited; according to recent Government publications the limit of self-sufficiency will be reached towards the end of the next decade, which after all starts in a few months'time. Towards the end of the 1980's we shall certainly be passing the peak of oil availability and may even be getting into difficulties over gas, as has already been foreshadowed. So we have a matter of 10 years in which to adjust ourselves to this energy problem. We have in fact ten years more than virtually every other large industrialised country in the world, which is a big advantage which we must not misuse.

I have no doubt at all about how we should set about solving the energy problem. As natural gas and North Sea oil begin to run out we have three inter-related solutions to the problem on which we must make decisions now. One is to develop alternative sources and those alternative sources are coal and nuclear energy. The next thing we must do is to have a very positive approach to energy conservation and efficiency in use. Finally, we must accelerate energy research, so the policy is clear; no policy in Britain has ever been clearer than the policy we need to pursue on energy at present. It is to make the best use of this enormous natural advantage we have from the North Sea but then to make absolutely sure that that phase is going to be followed by a period when we can still be self-sufficient in energy, by a combination of developing the longer term energy resources which we have, and by making use of energy more efficiently. Let us be quite clear the other sources of energy which we frequently talk about - solar, wind, tidal and the rest - are going to make an increasing contribution, but by the end of this century, at any rate, their contribution will still be minimal.

Now where does the Society fit into this? In my opinion it fits in with recognising the facts of life in the first place.

e have got to develop the energy sources we need; having done hat we must then make sure that those energy sources are eveloped and used in a way which will create the minimum disturance to the environment. That in my opinion should be the policy o be pursued by this Society in as vigorous a public manner as ossible. Every source of energy contains potential environental problems; whether it is oil or gas or coal or nuclear ower or tidal energy or wave energy, they all have their envirnmental disadvantages. And so I would suggest that it is the ask of this Society to identify the problems that the various nergy sources present, and to suggest how these problems can e overcome. That is the task, and I would like to say a word r two about the coal industry's approach to this problem.

he coal industry is an old industry. There are relics of he burning of coal by the Romans on Hadrian's Wall; according o the ashes that have been found there, the Roman legionaries ere apparently warming themselves with coal, so coal burning oes right back to that period. Since then of course the coal ndustry has developed and was the source of the Industrial Revolution, and within living memory coal has been regarded as something absolutely essential to life. Now we are trying to build a new industry out of an old one, because we know full well that coal represents the largest reserve of fossil fuel in the world. Fossil fuel, represented by natural oil and natural gas, is limited, whereas fossil fuel represented by coal is virtually unlimited. So the challenge is not to say let us stop using coal because there are other more conventional sources currently available; it is to say let us use more of it but let us use it more efficiently and in a more environmentally acceptable way.

When the Clean Air Act was introduced in the early 'fifties the coal industry wholeheartedly supported it. It was proposed that in parts of the country which were heavily populated visible pollutions in the form of smoke and dust should be eliminated and the coal industry consistently supported that policy, by supporting everything that was done to ensure that only smokeless fuels were used in those areas, and that heating appliances were developed in such a way as to assist in that objective. Although clean air legislation created serious problems for the coal industry, these measures were accepted as an overriding social requirement. Furthermore, the coal industry recognised that the mining operation itself could create a lot of environmental problems in other ways, by subsidence, pit heaps etc. A very serious effort has been made to minimize the problems created.

They cannot be altogether eliminated, because if mining operations had to be made invisible, the industry could not exist. When coal mining operations are started, some visible signs cannot be avoided; what the industry tries to do is to minimise the difficulties created by its operations . In other words, it is an approach based on compromise between the requirement for the energy on the one hand and the need to diminish the environmental impact on the other hand.

Lord Flowers is the Chairman of the Commission on Energy and the Environment, which intends to deal with this problem, and they have decided to start with the coal industry. The Coal Board is giving them every possible support in this endeavour. One of the members of our Board has been nominated to give every assistance to the Committee for this purpose. The Board have provided them with all possible information, because we fully subscribe to the idea of reconciling energy needs with environmental needs. If that attempt is not made, Britain would end up in the same situation as the Americans. They have an undoubted energy problem, but the way in which they have dealt with the environmental issue is such that they run the risk of defeating their energy objective as a result of the environmental constraints they have imposed. Recently they have agreed among themselves that this is something that ought to be put right, and under President Carter's latest proposals, they have set up a body which is trying to find a solution. There are as many as 27 agencies in the United States concerned with environmental problems, and if anybody in the coal business tries to develop a new coal mining operation (and it is very much in the interests of the United States to diminish their substantial dependence on imported oil) they have got to get agreement with the vast number of agencies before they can start. On top of that, the user of the product has got to obtain an untold number of authorisations before he can use it. This strikes me as being the wrong way to handle a problem, so we ought to study the American position with a view to avoiding those pit falls. They have now realised that they cannot operate that way. We must not get into that situation.

So my concluding remarks are very simple. We have two problems; we have a problem of making sure that in the years ahead we maintain as far as we possibly can our energy self-sufficiency. On the other hand we must aim to do that with maximum possible regard to environmental standards. This is much more difficult than simply saying we are going to get energy at any cost, or that we are going to protect the environment at any cost. These days people tend to take up a single position, but life is not

simple. Life is a matter of sensible compromise. In my opinion, it is a much more difficult message to get over than the simple message of going for the one or the other, and so that is the proposition that I recommend to this Society to which I have the greatest honour to belong.

I would not like to finish without paying tribute to Admiral Sharp, because his has been a great name in the affairs of clean air for many years. Indeed he has headed the executive of your Society for 12 years, and at the end of this year of course he will be giving up his office. He has established for himself and for the Society not only a national but an international reputation. He has been a very vigorous member of the Clean Air Council as well. That body's life-span seems to have come to an end, although there is some uncertainty because of the statutory aspects. While that is regrettable in some ways, if it should be the end of the Clean Air Council, I think that would mean that the Society's role would become all the more important. I would like to thank you, Mr. Chairman, and your colleagues, for the honour you have done me, not only in asking me to be your President, but also in asking me to come along today which has enabled me to pay tribute to Admiral Sharp for what he has done over the years. Indeed, I pay tribute to all your members who fight so hard for the very desirable objective of clean air, and to plead if I may as an energy producer that you will regard this question of reconciling the energy needs and the environmental needs as your prime objective in the years ahead.

SESSION 6

FACTORS AFFECTING ENVIRONMENTAL SOUND PROPAGATION - Mr. H.S. Gill and Professor J.B. Large, Institute of Sound and Vibration Research

THE EFFECTS OF WEATHER ON NOISE MEASUREMENT AND ASSESSMENT - Mr. P. Sutton, Esso Petroleum Co. Ltd.

Mr. G Barrett,(Central Electricity Generating Board) opening the discussion, said that when he was a child, his family had lived 1½ miles from the local parish church. Among the locals it had been well-known that if on Sunday morning the church bell could be heard it was fairly certain that within 24 hours it would rain. Even as a child his uninformed mind had turned to thinking about what exactly was the property of the sound from those bells that brought about rain, and he had even wondered why, if they were going to cause rain, the bells rang at all. Since that time, his interest in both campanology and acoustics had grown, so that he had come to realise the importance of weather in terms of noise, and he thanked the authors for their excellent papers, commenting that he had seldom heard such a thorough review of the subject of sound propagation.

Dr. Gill had reviewed the theoretical aspects of sound propagation, some items of which had been very worthy of comment. The stress laid on the urgent need for more research into the effects of refraction had been notable. Also noteworthy was that the effects of precipitation, turbulence and temperature profiles could be considered to be neglible for propagation under small instances. Mr. Barrett said he had been impressed by the final conclusion, that very little research had been done into sound propagation at night. Considering how common it was actually to go out to measure sound from installations at night, as Mr. Sutton had described, and also to measure the background noises at night, he found that a surprising and serious omission.

Mr. Sutton's paper had fully complemented the previous paper, and stressed the practical aspects of sound propagation. Mr. Barrett found it interesting to know that practical experience indicated that wind direction was the most important single factor causing variation in noise propagation. That factor had not been emphasised in the more theoretical paper from Mr, Gill. Mr. Barrett suggested that it was not only wind direction that was so important , but also variations in wind direction and wind speed which had a very important effect on noise and to a great extent determined the results plotted on Mr. Sutton's graphs. He had

also been interested in Mr. Sutton's conclusions that the specified conditions for the 1976 Noise Measurement Regulations could only apply for about 5% of the time; when annual leave was also taken into account , Mr. Barrett suggested that there would not be much time left, even of that 5%. He thought that was a very important lesson for those who drew up such regulations and he hoped that they would take it very much to heart.

The papers had also given details of the effects of climate conditions on noise propagation. The subject of the conference was, however, weather, and Mr. Barrett emphasised that climatic conditions and weather were not at all the same thing. He was sure that Mr. Jack Scott, who had addressed the conference earlier, had been only too well aware that while weather forecasters could predict climate conditions with a fair degree of accuracy, they nearly always got the weather wrong. The difference lay in the fact that weather was the sum total of all the climatic conditions, and as Dr. Gill had pointed out, when those conditions were all taken together and considered in the context of noise propagation, the situation might be very difficult. He was sure that he was speaking for many in the audience, especially those such as Environmental Health Officers who were engaged in planning work, when he said that what was needed were a few simple tools which would enable the agglomeration of climatic conditions known as weather, to be tackled on a sensible scientific basis. In that context, he referred to the great work done in the field of air pollution by Pasquill, and reminded delegates of Pasquill's weather classifications which had brought about a great simplification in the treatment of weather and air pollution. People had progressed to more scientific details, but Pasquill's methods were still being widely used and were widely respected. Mr. Barrett had been pleased to see reference to Pasquill's work in the papers and presentation of Mr. Sutton. He wondered whether more could be made of that type of approach on the subject of noise propagation; the Pasquill categories had after all brought together a lot ot weather practice: inversions, temperature, cloud cover, wind speed were all there, and Mr. Barrett wondered whether a similar sort of classification might be useful in dealing with the subject of weather and noise.

He asked the authors to comment on whether it was sufficient in planning methods simple to ignore the effects of weather on sound propagation, as was done at that time. If that was not sufficient, was it necessary to plunge into the detailed calculations given by Dr. Gill or would there be available in the

near future, those few simple tools to which he had referred, tools that might perhaps be based on the sort of weather category Pasquill had produced, simple tools which would allow simple coverage of the effects of weather on sound propagation.

Professor R.S. Scorer (Clean Air Council), commenting on the nature of received sound levels, said that many people were given in high school a very misleading picture of the discriminating power of the human ear. For example, it was often asserted that people could not tell whether a noise was directly behind or directly in front of them: Professor Scorer said that was because the senses took note of effects of the difference in the shape of the human head and ears, at the back and front. People could pay attention to parts of the general noise around them which they chose to listen to, and could be alerted by the occurence of noises significant to them. He pointed out that there was no tape recorder which could capture what people could hear anything like as well as photography could record the important aspects of what people saw.

He illustrated his point by noting the widely held belief that trees absorbed sound significantly more than open ground. He said that in fact they had a very small effect in that direct physical way, but that if they obscured the view of a traffic-laden road, they could alter the nuisance value of traffic noise a great deal. Visual obscuration of the source could increase the restfulness of a park or common very considerably, but it might be less effective in other cases because awareness of the nature of the source was not always reduced: the sight of one road might make the noise from another more objectionable.

Falling snow could scarcely exist without snow on the ground. A snow cover, including that on trees, could have a deadening effect on noise and make early morning weekday urban traffic sound like Sunday. It also had an effect in reducing the output of traffic noise by altering both the behaviour of traffic and the nature of its physical impact with the ground. Likewise a wet road produced a different quality of noise, which might be more acceptable, even if the traffic movement and density were not altered by the wetness.

Mr. G.R. Charnley (Southampton City Council) first thanked Mr.

Gill and Mr. Sutton for clarifying the whole position on noise assessment.

He said that in his paper, Mr. Sutton, whilst he had qualified his statement to some extent, had stated that annoyance from noise depended on noise level and character and that the measurement of noise in 'A' weighted decibels took care of the general character (i.e. frequency content).

Mr. Charnley thought there seemed to be a tendency, especially since Britain had joined the EEC, to standardise everything and to introduce universal indices to cater for all situations. Leq and 'A' weightings were in fashion. Having attended a recent seminar at which Dr. Leventhall from Chelsea College had given a paper on low frequency noise, and speaking also from his own experience as an Environmental Health Officer in dealing with some low frequency problems, he felt that the temptation to assess everything in dB(A) terms should be resisted. He cited a recent example , where boiler fan intake noise had given rise to significant noise problems in a nearby house with levels of 22 dB(A) in the bedroom and 27 dB(A) in the lounge arising from narrow band noise at around 30 Hz*. Sound levels of 30 to 35 dB(A) were often quoted as being acceptable for sleeping.
(*Ref: 'Noise control vibration isolation' - a case history of a low frequency noise problem, P.F. Chatterton. Noise Control, Aug/Sept. 1979).

He quoted from Dr. Leventhall's paper: "Noise criteria are, in general, deficient in dealing with low level noise and are particularly so when the noise is of low frequency as well as of low level. Significant changes at the low frequency end of the spectrum may have a negligible effect on the dB(A) level, but be clearly perceptible. In general, low level/low frequency noises become annoying when the masking effect of higher frequencies is absent. This can occur, for example, in the transmission through walls and in a propagation over long distances, since in both cases higher frequencies are attenuated more readily. An important factor appears to be the rate of fall of the spectrum in the mid and higher audio frequency ranges. The more rapid the fall off, the more annoying is the noise."

He felt that aspect to be particularly pertinent when considering the petro-chemical industry where relatively low frequency sources and comparatively large distances between source and receiver were common. He did not deny that in general the 'A' weighting related well to human subjective response but said that until more had been learnt about low frequency problems, it should be

remembered that 'in general' was not all-embracing.

Referring to figure 5. on page 8. of Mr. Sutton's paper which gave the results of 'nightly' measurements over a period of one year, he asked whether, taking into account that in his estimation there were less than 18 nights in the year when noise levels could satisfactorily be measured, Mr. Sutton could expand on how his data was obtained.

He said that insofar as noise abatement zones and the Measurements and Registers Regulations were concerned, Mr. Sutton was unlikely to meet himself (Mr. Charnley), as an Environmental Health Officer, on site after 11.00 p.m. anyway; not because Mr. Charnley would be in bed or because he did not wish to control and improve the noise climate, but because while applauding the concept of noise abatement zoning, the methodology contained in the regulations, in his opinion, left too much to be desired.

Leq, L_{AX}, L_{10}, L_{90} and now $L_{downwind}$! He explained that the Fawley complex was situated to the west of Southampton Water and, as well as the Esso Refinory, there were a number of other chemical industries, and power stations, and so on in the area. When the wind blew from the west and south-west, complaints were made, on occasions, of unpalatable odours; he wondered whether Mr. Sutton had considered using L_{dw} as a dual purpose index to be used both for noise and smells as confirmed by the complainants who would say it certainly was "L downwind" on such occasions.

Mr. A.G. Sills (Meteorological Office, Royal School of Artillery, Larkhill) began by outlining the problems of noise at an artillery range where the sound intensity at the gun position could exceed 170 dB. Similar conditions apply at quarries. This sound could propagate over a wide area giving rise to complaints from the public or even damage at a distance of over 10 miles.

He then described a sound ray tracing technique that had been used for over a year with encouraging success. This method employed a small computer to calculate the number and ranges of the sound rays that returned to earth and, using an empirical formula developed at Larkhill, estimated the sound intensity.

He said that the data required for the computer were winds and

temperatures at 150M height intervals from the surface to about 2000M, and that these were measured every two hours. The result showed that

(1) wind shear was a major factor in sound propagation. Shears of 20kt (34ft/sec) from the surface to 2000M were by no means uncommon - it would require an inversion of 17 deg.C. to produce a similar effect.

(11) sound focussing occurred when the speed of sound decreased with height and then increased. In those conditions, the sound intensity at a given point might be increased by a factor of 100 or more.

(111) sound focussing could occur at a location when there was no wind at any height blowing from the source to that location. The required wind shear in those circumstances was caused by a change of wind direction with height, a common feature near fronts.

The speaker concluded by saying that in his opinion measurement of sound away from the source (up to a distance of about 40KM) must include measurement of wind and temperature profiles for the readings to be valid. Small fluctuations in sound intensity were occuring all the time but significant changes could be expected during a period of two hours.

He then asked Mr. Gill and Mr. Sutton:

1 Whether they were aware of the importance of measuring wind and temperature profiles at frequent intervals during sound measurements.

2. Whether they knew that sound intensities could be enhanced by orders of magnitude without a single wind at any level blowing from the source to the point of measurement.

3. Whether any approach had been made to the Meteorological Office to provide wind and temperature profiles to assist in the assessment of noise distribution and intensity.

4. What was the sound reflection co-efficient over a water surface?

5. What was a typical sound intensity at the boundary of a factory complex?

Mr. I.W. Barker (Sheffield Metropolitan District Council) said that he was always suspicious, being an unimaginative bureaucrat, when someone with Mr. Sutton's stand-point professed to be

enamoured by BS 4142. It usually meant that they had interpreted it in a manner most beneficial to their own viewpoint.

He did not agree that the noise of an offending factory or works could be equated with the background noise level of the area in which it was located. In 1968, being bedevilled with the problem of how to arrive at a valid background noise level, he had sought the advice of Dr. Robinson of the National Physical Laboratory, who had originally conceived BS 4142. Dr. Robinson had confirmed that the averaging of a number of measurements taken within a quarter mile radius of the offending factory was an acceptable method of arriving at a background level for the general area within which it was located. It was not necessary for the background level in the immediate vicinity of the factory to be assessed. Mr. Barker said it should not be forgotten that, as originally conceived, BS4142 had been intended as a planning tool to be used to predict the likely impact of a proposed development, or of a new process, on a pre-existing situation. In such circumstances it would certainly be invalid to regard the new noise as being part of the background noise because, until the new development was completed or the new process installed, the new noise would not exist. When it did occur it would most certainly be superimposed upon the pre-existing background level.

He agreed with Mr. Sutton that the basic essentials for noise assessment were a pair of ears and a sound level meter. Environmental Health Officers had known that since 1960, when they had been called upon to make practical assessments of noise without any assistance from academic or scientific institutions who, at that time, had not embarked on research into the practical problems of noise assessment. EHO's therefore had had to develop their own empirical methods. He respectfully suggested that it was late in the day for Mr. Sutton to start to teach his grandmother to suck eggs - 20 years after the event.

Mr. J. Norton (Leeds City Council) asked whether Mr. Sutton felt that nuisance could really be assessed by using BS 4142 or ISO 1996, bearing in mind that 'nuisance' was a legal term and should be based on the monitoring officer's subjective impression.

Dr. J.M. Richards (Individual Member) said that at night, most

householders lived upstairs inside houses, and for them it seemed inappropriate to measure sound within 6 ft. or so of ground level and in the open air. He asked the speakers to comment. He also wondered whether the effects of room reverberation and/or resonance altered significantly the amount and/or character of sounds or vibrations perceived within a bedroom (compared with levels outside the bedroom window). He asked whether such changes might be particularly noticeable for impulsive incident noises or incident sounds of low frequency.

Mr. H.S. Gill replied to Mr. Barrett's questions, as to whether it was sufficient to ignore the weather in outdoor sound propagation. The simple answer was 'No', but Mr. Gill pointed out that some practical difficulties had to be faced in actually obtaining data on the meteorological conditions when carrying out sound measurements. Some people, like Mr. Sills, could provide facilities which would be probably useful for orchestration but generally there were no facilities available so that no useful information could be obtained. He wanted to simplify the matter and make it clear what acousticians generally tended to believe. The general practice was that the wind might vary one day from a particular direction to an opposite direction the next day, so that one day there might be an increase in sound, and the next day there might be a decrease in sound. Overall the effects were probably more or less cancelled out, so it was probably fairly reasonable to assume that the effect of wind could be ignored. That was true for general practice, but obviously with intense sources like artilleries, or rocket-launching sites, it was very important to obtain information on meteorological conditions and use the ray-tracing techniques described in the paper, and elaborated on by Mr. Sills, to determine any possible focussing of acoustic rays. With a rocket launching site, breakages of windows could occur almost 80 miles away due to particular meteorological conditions.

Professor Scorer had raised the question of whether the falling of snow had any attenuating effect on the propagation of traffic noise. Mr. Gill stated that the effect of snow falling through the atmosphere had a negligible effect on the propagation of sound through the atmosphere. However, the falling snow did cover the gound surface and perhaps that would have an appreciable effect on the propagation of sound over the newly snow covered absorbing ground surface. Mr. Gill further stated that he was not aware of any literature which dealt with

the propagation of sound over a snow covered ground surface; obviously that was one area which needed looking at.

Professor Scorer had also raised the question of whether trees were effective enough to reduce sound propagation. The figures Mr. Gill had actually given were that at a frequency of 1,000 Hz an attenuation of only 10dB would be expected with a tree width of 100 m, which meant that a large width of trees would need to be planted to have a reasonable attenuation. That could probably not be done in the UK, but in America they had tried planting trees up to 50/100 m. It was probably psychologically more important to plant trees, because it gave a large distance between the observer and the source, as for example a highway with a tree belt. In Great Britain there tended to be barriers around longer roadsides because of the houses situated very near the roadside and the barriers were very much more effective in that situation.

Turning to Mr. Sill's discussion about sound ray-tracing techniques, Mr. Gill thought that he too would agree that the use of meteorological data was invaluable when dealing with the possible focussing effects from intense noise sources, and pointed out that it sometimes could be very difficult to obtain the necessary required meteorological data, since the atmosphere is always unstable and therefore it would certainly be required that meteorological data be available at quite frequent intervals, perhaps from hour to hour, during the acoustical field measurement periods; obviously it was not always possible to get all the necessary information even every couple of hours from the Met. Office. Mr. Sills had obviously given considerable thought to the effects of wind and temperature; Mr. Gill said that he himself had certainly not been aware of the fact that sound enhancement could occur at receiver position even when there was no wind blowing from source to receiver location. As far as the sound reflection coefficient of the water was concerned, he did not have any figures, but he expected it to be nearer to 1.0. Therefore, the sound propagating over water would be expected to have an almost negligible excess attenuation. It certainly would travel greater distances over water than over ground.

Mr. P. Sutton replying, said that every one had a lot to learn from each other and that industry and local authorities between them had got to work together on the whole problem of sound propagation and measurement; the standards were inadequate and inconsistent: a way of sewing them up so that they joined

together had to be found, and he felt that the discussion had been most helpful.

He turned first to the comment by Mr. Barrett, who had suggested that wind vertical velocity gradient was more important than wind direction. Mr. Sutton said that he had referred to wind direction, because that was all that could be seen and measured near the ground but that it was indeed the vertical gradient of wind velocity that really mattered. Mr. Barrett had also asked whether use was made of Pasquill's work. Mr. Sutton said that he believed that he himself was the first acoustician to have heard of Pasquill, and as far as he knew was the first to have used Pasquill Stability classification, which he had done for the last 12 years. He was a great believer in Pasquill; it was not necessary to use thermometers and balloons, it was sufficient to use a hand-held anemometer and look up at the sky to find the appropriate stability class.

An interesting point was that in one of the most important papers, internationally, on sound propagation near the ground, that by Parkin and Scholes, (1) the measurements were all made between 10 a.m. and 2 p.m., so the atmosphere was always unstable or neutral. Very little scientific work of this nature was done at night when stable conditions are common - scientists tended to concentrate on easy jobs, leaving the more inconvenient tasks to engineers.

Professor Scorer had mentioned the value of ears and Mr. Norton had said that nuisance was subjective. Mr. Sutton agreed with that. He said that pollution was not just a matter of micro-crammes per cubic meter, but also a matter of smells and dirt. Noise was not just a matter of decibels, it was also a matter of intrusion and what keeps people awake. What he was trying to do was to find some way of getting an idea of the decision to which the court would come if an action for nuisance were brought. He said that, with all due respect to Mr. Norton, it was not the environmental health officer's opinion of whether the noise was a nuisance that decided the issue, it was the court's opinion which decided whether it actually was a nuisance in law or not, although obviously the environmental health officer's opinion was tremendously valuable.

He had been a little puzzled by some of the comments on BS 4142 with regard to its use for planning purposes; since it uses measured works noise level it was clearly designed for existing situations, though using the appropriate correction in paragraph

A2 it can be used for planning purposes. He beleived that BS 4142 was well-designed and comprehensive, and could be applied to most situations although it could also be misapplied. In the oil industry, it had been found to be very useful in interpreting existing situations and he would come back to that point in connection with ISO 1996.

Mr. Richards had asked about the effect of room dimensions, and Mr. Charnley had commented on low frequency noise. Mr. Sutton said that indeed, measuring in dB(A), it was only possible to generalise on what the noise regime was likely to be inside the house given a "normal" noise spectrum outside. It was important that indoor noise should be measured indoors, in other words, noise nuisance had to be measured where it occurred not somewhere else. In connnection with enhancement within houses, room dimensions and the noise frequency spectrum were very important. With regard to elevation, for a distant source the difference between noise levels outdoors at ground floor and first floor window elevation was in his experience small.

In connection with the dB(A) scale he said that some years previously there had been Zwicker Phons, Din Phons,NR Curves, NC Curves and a whole rigmarole of parameters. Eventually it had been found that the simple A weighting correlated as well with response as anything else (as well or as badly). He hoped Mr. Charnley would agree that in 90% or more cases the dB(A) was adequate, but it was necessary also to use the evidence of the ears along with the dB(A). There was, of course, an allowance for pure tones in BS 4142, the magic 5 dB that was used also in ISO 1996, but obviously that could not always be right. An audible pure tone might be worth 5 dB, a prominent one 10, a dominant one 15 dB.

With regard to Mr. Charnley's comment on L-downwind as an additional unit, Mr. Sutton said that he proposed it for simplicity. The Noise Advisory Council proposed the use of Leq. which was adequate for periods of up to 24 hours, but the 1978 draft of ISO 1996 proposed the use of year-round Leq. This was nonsense first because it was difficult and often impossible to measure and second because it was irrelevant. The L_{dw} is the easiest parameter to measure, the most relevant to nuisance and quite reasonably what the Regulations required.

Turning to the psychological effect of trees, he said that nuisances were what was noticed, not what was measured with an instrument. He agreed with Professor Scorer that trees had important

psychological value. Technically, trees were not an acoustic baffle, but psychologically they were a nuisance baffle and, therefore desirable.

Turning to Mr. Sills contribution, he said that Mr. Sills was evidently doing some tremendously useful work, and he asked him how much of it was going to be published as there were many people who would be extremely interested to read it as such information was really needed. On the question of using Met. Offices, Mr. Sutton said that certainly they were used, but the problem was that there was seldom a suitably equipped Met. station near enough to the actual workplace or the actual housing estate. The layer of the atmosphere that interested those concerned with industrial noise on the ground was the first 100 meters or so which was below the level that was particularly interesting to the meteorologists and therefore the Met. Office generally could not give the relevant information. It was necessary to make particular measurements oneself, or to look at the sky and feel the wind and make a rough and ready assessment of stability and wind gradient.

Referring to Mr. Barker's comments Mr. Sutton said that he was sorry if he had given the impression of equating background noise with works noise. What he had meant was that it was necessary to determine whether the measured noise was background or works. The meter could not distinguish and in that situation it was also necessary to use the ears and listen. In some situations, particularly with continuous process works, it was impossible to measure the background independently. There were then two possible courses of action. One was to go to a similar area a little further away from the works, measure the background and reckon that that would apply at the works site; another was to use a notional background.

ISO 1996 had been advocated in preference to BS 4142, but what he disliked about 1996 was its spurious sense of accuracy. Firstly there was within 1996 a choice of basic criterion; if the high basic criterion was taken, and the minimum night correction applied, there would be in most cases the same predicted complaint threshold as if BS 4142 had been used; what it went on to do was to pretend that having done that it was possible to predict whether there would be no complaints, sporadic complaints, widespread complaints, threats of community action, or vigorous community action. That simply was not possible. He showed the results of a Concawe survey to illustrate that point.(2) The

data both on complaints and on noise levels had been collected by the refineries concerned. It was therefore, perhaps totally untrustworthy because it had been collected by commercial organisations for their own propaganda purposes? He hoped, however, that he had been able to give some impression of integrity, if only because it was more fun to be honest, as it lead to more lively discussion! Quite genuinely, he felt that the data were about as good as could be obtained. What had been found was that for a number of locations near a number of refineries within Europe, if the average works noise level was 10 dBA below the notional background (from BS 4142) then roughly 80% of refineries had no complaints and 20% had some complaints; if it was 10 dBA above notional background, roughly 80% of refineries had complaints, 20% had had no complaints. In other words, even that 20 dB spread was not a 100% secure, it was only an 80% predictability as to whether there would be complaints, or not, and trying to narrow down to 5 dBA predictions as ISO 1996 did was completely unrealistic.

He showed a detail from an important European Community Expert Committee document (3) (Professor Large had been one of the authors). He had made reference to the document in his paper; it used a slightly different method of normalising, which was essentially the notional background approach, used backwards. No reaction had been recorded in some situations where vigorous community action would have been expected from ISO 1996. He pointed out that most of the data was from a simple urban factory type of situation, not a mile away from a chemical works or refinery; it had been essentially data collected in the simplest sort of situation, analysed in the most sophisticated manner. There was still 10 dBA spreads, big overlaps between no reaction and widespread complaints, so that clearly it was only possible to have a rough guide, which BS 4142 gave. His experience in the oil industry was that BS 4142 was a useful rough guide, and said that if anyone had experience that it did not give useful guidance, it would be very helpful to publish that information.

Mr. Sutton had overlooked Mr. Charnley's comment on fig 5 in his paper. He explained after the session that the 18 measurement days per year referred to measurements strictly in accordance with the Regulations. The measurements in fig 5 (and fig 6) were made whenever conditions were in fact suitable for noise level readings, which in a sheltered locality in south-east England amounted to about 250 days (nights) per year if all wind directions were included.

References: (1) Gill and Large paper ref 26.
(2) Sutton paper ref 11.
(3) Sutton paper ref 14.

SESSION 7

THE ACCURACY, INTERPRETATION AND USE OF RESULTS OBTAINED FROM MONITORING AND MEASUREMENT OF AIR POLLUTANTS - Dr. M.J.R Schwar
Greater London Council

THE EFFECT OF POLLUTION ON CLIMATE - Dr. B.J. Hoskins,
University of Reading

Dr. R. Barnes (Esso Research Centre), opening the discussion, remarked that the strenuous programme of the previous two days had taken its usual toll on the audience for that last session; this was unfortunate since the two papers under discussion represented the natural climax of the conference. They had dealt with effects and that was what it was all about. If all the effects of air pollution, or the potential effects, were thoroughly understood, then he himself would not be employed, nor would many others in the audience. The two papers had represented the two extremes of interesting effects. Dr. Schwar's paper would have interested many delegates, dealing as it did with essentially parochial interests. Such grassroots incentive for study was very important, but he did not think the effects were themselves of any major consequence, on a wide scale, although they were the prime responsibility of the GLC. He thought that Dr. Hoskin's paper had given an indication of the situation that could develop if pollution had a major effect on climate; the feed-back mechanisms that had been mentioned had potential to change local climate on a very substantial scale. He thought that the results in terms of political, economic and social impact could be quite enormous. Referring to the Wars of the 9th - 10th Centuries and the invasions of Great Britain, he said that British culture would have been totally different if it had not been for a climatic recession in the post-Roman era.

He wanted, after those general remarks, to take up a few specific points that the two speakers had raised. He had to talk from their written presentations as he had not been able to see their slides from his position on the stage. The first point, which he did not think Dr. Schwar had referred to in his verbal presentation, concerned the variation of up to a factor of 3 in smoke and sulphur dioxide concentrations measured at sites only 500 metres apart; Dr. Schwar had given this statistic in the context of the very complex proposed EEC SO_2 and particulate Draft Directive. Dr. Barnes wondered how any form of legislation as complex as that proposed Directive could be put into operation effectively when the monitoring sites were so sensitive to variations of concentration over such a short distance. He thought that the legislators should turn their attention to the problem.

He had also been very interested to hear cigarettes being mentioned. Enormous effort was being put into the study of air pollution and even more effort into trying to find what effects it had, yet there were tens of thousands of people dying each year from cigarette smoking - admittedly a self-inflicted form of pollution. This seemed particularly ironic when the Governmant was so anxious to protect workers from themselves with the Health and Safety at Work Regulations (his own job was being made extremely difficult by regulations that were designed essentially to protect him from himself). Additionally there were enormous efforts being made to come up with new road signs, flashing lights on motorways and overhead lighting at motorway junctions: hundreds and thousands of pounds of research perhaps just to save one or two lives a year. But the banning of cigarettes would probably save, in the UK alone, about 50 thousand lives a year. Dr. Barnes thought that the balance was a little wrong somewhere. He was very pleased that Dr. Schwar had brought up a matter which Dr. Barnes regarded as hypocrisy of the first order.

Dr. Barnes turned to the discussion of guidelines, which Dr. Schwar had dealt with in detail. Dr. Barnes felt that certain of those mentioned by Dr. Schwar were not related to effects and cited the lead guidelines as used by GLC, for which the justification had been a piece of GLC work. He wondered whether the figure of 5 microgrammes per 100 millilitres of blood was medically significant, and asked Dr. Schwar to explain exactly what the significance of that guideline was, as it did not seem to be related to effects at all. He thought that the ozone guideline was particularly meaningless and asked on what effects basis the GLC's ozone guideline had been devised.

He said that from his own experience in central government, he knew that HMG were not keen on guidelines, for what he regarded as very sensible reasons. Guidelines were about as sensible as the 30 mile speed limit; everyone knew that a 30 mile speed at 2 am in the morning was completely meaningless and a 30 mile per hour speed limit on the same road at 9 o'clock in the middle of the rush hour was equally meaningless. The most effective technique, in relation to travelling at excessive speeds on roads, was to term it 'dangerous driving' or 'driving without due care and attention'. In terms of the area covered by GLC, Dr. Barnes felt that some of the guidelines that GLC had implemented would be somewhat irrelevant in the Park Royal industrial estate, where a healthy,adult, generally male, workforce were employed, and none of the old aged pensioners and the

young children at risk in other areas could be found. He thought that such arbitrary guidelines were not as useful as a more pragmatic approach.

Turning to what he thought was a very useful paper by Dr. Hoskins, Dr. Barnes said he had been very pleased to see a particularly moderate attitude taken on global climatic change. He said that it was a popular misconception that glacials were in themselves ice ages, a view fostered by the media and in particular "Nationwide" which tended at intervals to favour ice coming down the Thames the following Wednesday afternoon. He said that there had been a number of Ice Ages in past geological history, most of which had lasted about 10 million years; the present one had lasted about 1 million years, and mankind was certainly in the middle of it, existing in a temporary gap between glacials. He was sure nobody knew when the next glacial was going to come, but it certainly would not suddenly engulf the existing generation. He also thanked Dr. Hoskin for pointing out that the climate fluctuated quite naturally. He said that the energy inputs necessary to overcome the atmospheric heat engine were enormous, but some subtle effects could bring about changes. It had been known for some time that cities produced heat islands. The temperature in the centre of London had been known to be up 8^{o}C. warmer than in the surrounding countryside, and there were other differences, for example in humidity, in urban windfield etc. Another phenomenon, again related to pollution, was the widespread development,on a semi-continental scale, of summer haze, generally due to sulphates. The sulphates cut down the light and scattered certain wavelengths of radiation, so that, for example people could not easily become sun tanned. Sulphates also tended to make the atmosphere rather unpleasant, or 'heavy'. Visibility had, on occasions been affected on a continental scale.

He questioned Dr. Hoskins about feedbacks; after a very moderate lecture, Dr. Hoskins had concluded that carbon dioxide was if anything, likely to generate a global warming. Dr. Barnes' own reading of the literature led him to believe that the matter was not so certain; that there was certainly the potential for such a warming, but there was also a negative feedback in that cycle: the initial warming would be followed by increased water vapour content in the atmosphere which might in fact produce increased cloudiness, and with clouds having a very high albedo there would be a negative feedback. He asked Dr. Hoskins to explain his committment to the 'warming' theory.

Professor R.S.Scorer (Clean Air Council) said that the rapidity and extent of variations in cloud amount meant that the most important feedback mechanism in the atmosphere was a negative one, and that clouds were the chief agent for the stabilisation of climate. There was little prospect of being able to do very much about that problem in the 20th Century because the mechanism was so complex and varied over the earth. Perhaps in a few decades enough information might have been accumulated from satellites to make a small impression on the problem, but in the meantime the conclusions of modellers who habitually assumed that clouds were a given constant, or that they were not very patchy, must be viewed with mistrust.

He said that the session had produced a wealth of common sense which was worthy of congratulation: knowledge and skill in the field of air pollution management were developed best in practice, and theorizing about planning to be based on information yet to be collected by planned monitoring was more common in other countries; the UK effort should continue to be practically-based.

Referring to Dr. Schwar's presentation, he said that carbon monoxide was not of course the dangerous component of car exhaust; it was used as an indication because it was easy to measure compared with the really obnoxious components. He felt that the press and the media generally did not emphasise that point to the public. It was simply not correct to say that a small amount of substance, which could be lethal in large amounts, was proportionately dangerous; and small amounts of a great many pollutants were generally quite harmless. They only affected people who were at risk from other causes - mainly self-inflicted smoking diseases.

Mr. R.W. Lander (Middlesbrough Borough Council) referred to the fact that Cllr. Poole was his own Chairman of Environmental Health at Middlesbrough, and said that Cllr Poole had dropped a less than subtle hint that he expected Mr. Lander to come up with a few questions to help keep the session lively. Being a dutiful officer, he was taking the floor sooner rather than later so that the odds of another delegate asking the same questions were reduced.

He said that Dr. Schwar had given a clear picture of the valuable work which had been and was being done by the GLC Scientific Branch. From his own personal knowledge he knew that many of

his Environmental Health Officer colleagues were envious of the vast array of sophisticated monitoring equipment which had been made available to Dr. Schwar and his colleagues at County Hall, Westminster.

It was the declared policy of the GLC that its role should be that of a strategic planning authority and therefore they had seen fit to establish Air Quality Guideline levels based on the advice of their own officers.

Most of the information about smoke and SO_2 levels in London had been gathered by the Borough Councils Health Departments and the responsibility for enforcing the provisions of the Clean Air Acts and the Control of Pollution Act rested with the Borough Environmental Health Officers and the Alkali Inspectorate.

He was not aware that any liaison had taken place between the GLC and the Borough Councils before specific air quality standards had been established, which in his view was regrettable.

In his paper Dr. Schwar had stated that "the GLC has responsibility to see there is no overall deterioration in London's air and where possible to ensure that improvements take place". In view of his earlier comments, Mr. Lander asked Dr. Schwar how he envisaged the GLC achieving that objective, apart from through their control of major roads schemes.

He remarked that Dr. Schwar had referred to both the WHO and EEC standards for particulates and SO_2. At Figure 1 he had shown the trends in per centum of National Survey sites in Greater London not meeting WHO long term goals. It appeared that some 95% of the sites were failing to achieve those standards in respect of SO_2 and some 13% in respect of particulates. Mr. Lander asked whether, in view of the proposed lower EEC standards, Dr. Schwar could give an indication as to what percentage of sites would fail to achieve those standards.

Mention had also been made of the effects of various pollutants on the health of certain sections of the population. Mr. Lander thought it would be appropriate to advise conference that Middlesbrough Borough Council was currently undertaking the second phase of an investigation into the effects on health resulting from the exposure to concentrations of NOx in the home. A preliminary look at the results obtained during phase one suggested a very strong link between certain respiratory illnesses and recorded high levels of NOx.

He said that further information on that subject would be released when all the relevant information had been collated and verified. He felt that conference would also be interested to learn that one of his Principal Environmental Health Officers was currently assisting the EEC Commission on the assessment of standards of atmospheric pollution in relation to Middlesbrough.

His third question to Dr. Schwar was whether he considered that the UK local authorities would be at a disadvantage, compared with other members of the EEC, because of the extensive work which had been undertaken in the National Survey. Finally he said that he understood that the Cities of London and Westminster were seeking legislative powers to restrict the use, in their areas,of fuel oils to those with an SO_2 content of 1%. He asked whether Dr. Schwar would care to speculate on what effect, apart from a general reduction in overall SO_2 concentrations, those proposals, if implemented, would have on the quality of London's air bearing in mind the figures quoted at figure 1 in his paper.

Mr. T.A. Dorling (Warren Spring Laboratory) joined Mr. Lander in congratulating Dr. Schwar for his clear presentation of the air pollution measurements which could be undertaken by a large local authority and of how they could aid in the formulation and implementation of control measures.

He wondered what action, apart from the designation of smoke control areas by the local authorities, the GLC felt it could take to produce a general reduction in ambient pollutant levels.

He said that the CO levels (15-20 mg/m^3) and the annual mean air lead concentrations (1-3 $\mu g/m^3$), quoted in Dr. Schwar's paper as being typical of general levels in London, seemed to be unduly high, when compared with other measurements. He asked Dr. Schwar what had been the sampling time period during which the CO values had been obtained.

He then asked to whom did the general public complain about pollution from motor vehicles, and whether any records were kept. He said that the evidence for the extent of traffic nuisance was very sparse and any statistics could be valuable in putting this aspect into perspective. He said that although Dr. Schwar had produced a simple relationship between mean traffic densities and mean concentrations of pollutants, it should be borne in mind that the topography of the location, the types of building, intersections etc. could also influence pollutant levels. He

did however agree that some estimate could be made of likely pollutant concentrations in new situations by using such data. WSL measurements indicated that the concentration of kerbside NO_2 was very little higher than the urban background level.

He said that people should be careful, when using the term'smog', that they were not referring to the Los Angeles type smog which was unique, producing low visibility and lachrymatory effects. It was unlikely to occur in London as it was produced by a special blend of pollutants including high ozone concentration and short chain hydrocarbons.

WSL had carried out some comparative measurements of CO and NO_x in homes using electricity, gas and influed oil heaters for cooking and heating. Their findings tended to confirm the relatively high levels of these pollutants which Dr. Schwar had found.

He said that a drawback in working to guidelines and standards was not only that in different locations different acceptable pollutant concentrations could be tolerated but that confusion could arise when they were changed. He exemplified this by saying that the acceptable one-hourly mean concentration of ozone had been increased from about 160 to 250 $\mu g/m^3$ in the USA. He wondered whether the GLC was proposing to increase its air quality guideline for ozone by a similar factor.

He said that it was stated in Dr. Schwar's paper that in the UK there were no criteria against which to judge pollution levels. He reminded delegates of the TLV values and said that, without any other guideline, the TLV, or some fraction of it(e.g. TLV/40), was sometimes taken as a yardstick against which ambient ground level concentrations could be compared.

He said that there was, however, very little unequivocal evidence of the minimum levels of common pollutants (SO_2 , CO, NOx, Pb) which produced harmful effects in man. There was some evidence, mainly derived from high pollution episodes, that sufferers from respiratory and bronchial conditions could be affected by high smoke and SO_2 concentrations. There was a clear need for more information on health effects from medical experts and epidemiologists to help in deciding what were acceptable concentrations and in setting monitoring priorities.

Dr. M.J.R. Schwar, replying to questions, said that he would deal with guidelines first. He said that he had gone into the

question of why and how guidelines were used in his presentation, but that obviously some further explanation was necessary. He emphasised that the guidelines were intended as an aid in the assessment of the significance of a pollution level. They were of considerable value to officers in the reporting of measured pollution levels to Member Committees and Departments in the Greater London Council. Quoting pollutant concentrations on their own did not help in decision making, it was also necessary to refer the concentrations to some criterion related to associated health effects. The set of criteria agreed by the GLC to be used for that purpose had been based on recommendations made by an Expert Committee of the World Health Organisation and other expert medical opinion. The guideline for lead-in-air, referred to by Dr. Barnes, had been based on the same medical considerations used by the EEC in developing their draft directive for a lead-in-air standard.

Guidelines were not intended to be used in the same way as a speed limit might be applied in law. If a level was exceeded it did not necessarily mean there was a problem, but it would indicate that the amber light was flashing and that there may be cause for concern. This concern would be accentuated and possibly justified if particularly susceptible groups were likely to be exposed. It would clearly be undesirable for children to be playing in an area where there were high concentrations of lead. Someone had made the point earlier that such local effects of air pollution were of no major consequence. Dr. Schwar thought it would be totally irresponsible for a local authority to take that rather off-hand attitude to complaints from parents who were concerned about possible health risks to their children.

Dr. Schwar then turned to the suggestion which had been made by a delegate that there were standards by which local authorities could decide whether action needed to be taken, in such cases as road tunnels and car parks, and that the TLVs criteria, designed for occupational exposure, might be applied to the general public simply by dividing by a factor of 30 or 40. He said that if this were applied to carbon monoxide, it would result in a criterion of 1 ppm. Nobody would be able to drive through a road tunnel, or park their car in any enclosed car park if this criterion was to be applied. A more scientific basis for arriving at a standard was required, and he suggested that examining the consequences of exposure to CO (as he had done that morning), and looking at the dynamics of the elevations of blood CO levels would be a far better approach than taking an

arbitrary decision to divide an industrial criterion by 30 or 40.

There had been a number of questions related to the EEC Directive. He felt that he had shown some of the difficulties in London, if the country was to adopt a directive along the lines being proposed by the EEC. There was clearly a problem in defining the areas of London which would have to be subjected to emission controls in order to reach the requirements of the Directive. He had been asked exactly what areas of London would fail to meet the EEC Directive. He reminded delegates that the proposals in the draft Directive were extremely complicated, with all sorts of inter-relationship between smoke and sulphur dioxide, medians and annual means as well as daily values individually, and taken together.

Turning back to the question of GLC guidelines, and specifically whether liaison with the Boroughs would have helped, he said that his explanation of how the GLC tended to use and was using guidelines should be borne in mind; these guidelines were not mandatory, they were just helpful tools; if the Boroughs found them useful and were applying them to local situations that was well and good. They had not been intended to be used as a basis for Boroughs either throughout the GLC area or even as a national basis; it was convenient for the GLC as a strategic planning authority to use those guidelines for their own evaluation purposes.

Referring to the question about the concentrations of CO, and lead levels in London, he said that he had given the histogram of lead levels in London, which fell round about 1-2 $\mu g/m^3$; only one concentration with a level exceeding 3 $\mu g/m^3$ had been found. All values refer to long term means averaged over 12 weeks or so. As to carbon monoxide concentrations by a busy road in London, he thought that the information in the tables was adequate, but if it was not, he would certainly be willing to provide any missing details at a later date. The averaging periods were, he believed, indicated in the tables. On the effects of topography on local CO levels along busy roads, he said that theoretically there were many possible reasons as to why they might vary for different types of canyon situations. He thought that the results spoke for themselves; his slide of long-term average CO levels, with a whole range of canyon situations from urban to suburban, had demonstrated that the long-term means seemed to follow a reasonably good trend against vehicle density. Although from a theoretical point of view many important variables had been identified, in practice life did not seem to be, for a change, quite as complicated as the theoreticians might suggest. That

might be because the effects of some of the variables tended to cancel one another out when considering long-term averages.

Turning to the kerbside levels of NO_x, he said that the levels reported might, indeed, be similar to the background levels. His point had been that those were the values of nitrogen dioxide that had been measured at the kerbside and he had not necessarily been saying that they were different elsewhere; there might have been that implication from the table but he thought he had given a number of examples in his tables where oxides of nitrogen had been measured.

Referring to comments made on the relative effects of smoking on smokers, and the effects of ambient pollution levels on the population as a whole Dr. Schwar said it was not, in his opinion, right for cigarette manufacturers, Dr. Barnes , or even himself to say what levels of air pollution are acceptable. Ultimately he thought it was for the politicians, reflecting public opinion, to make that decision. But, it was his duty, an an officer in a strategic planning authority, to inform the decision makers of the concentrations, and as far as possible the significance of the concentrations to which people are exposed. Some people with certain heart conditions might find their health seriously affected if they smoked or they might suffer some disadvantage if repeatedly exposed to high ambient levels of carbon monoxide. Some smokers were apparently happy to accept this risk, while non-smokers might not wish to be disadvantaged in this way. It would be wrong to say that what was acceptable to one group was right for another.

Dr.B.J. Hoskins replying, thanked both Dr. Barnes and Professor Scorer for saying that his paper had been moderate; it had been intended to be moderate because he thought that was the way to approach the problem. It was necessary to try to see all sides of the problem, not make it into a scare story.

Talking about the possibility of an increase in cloud, he said that if the amount of water vapour increased in the atmosphere it would indeed be expected that the cloud would increase. Cloud tended to reflect some of the sun's radiation and it also tended to absorb some of the radiation from below and reradiate it at its own low temperature. The increased reflection of solar radiation would tend to lead for a cooling, but the increased absorption of Earth radiation would tend to give a warming. If

upper cloudiness was increased, then the warming effect of the increased absorption would be dominant, whereas if low level cloudiness increased, the reverse would be true. So increasing cloudiness did not determine what would happen to the atmosphere. It was necessary to know the distribution of that increase, and that was very uncertain, as Professor Scorer had suggested most of the available models did not include some idea of that effect. However, some did, and they did not seem to predict the negative feedback that Professor Scorer had obviously been hoping for, although Dr. Hoskins agreed that nothing was known for certain. That was the point he wished to emphasise - that there was uncertainty about the climate and the effects of CO_2 in particular principally through clouds and also through the ocean. The best estimate, taking into account all the models he knew of, was of a possible 3 deg.C. average warming if CO_2 levels doubled.

INDEX TO SPEAKERS

NATIONAL SOCIETY FOR CLEAN AIR

47TH ANNUAL CONFERENCE
22-25 SEPTEMBER 1980
BOURNEMOUTH

ENERGY, NOISE, ROAD VEHICLES AND SMOKE CONTROL

PART I
PRE-PRINTS OF PAPERS

136 NORTH STREET
BRIGHTON BN1 1RG, ENGLAND

47th ANNUAL CONFERENCE
BOURNEMOUTH, 22 - 25 SEPTEMBER 1980

GAS AND THE FUTURE ENVIRONMENT
W.R. Probert

OIL AND THE FUTURE ENVIRONMENT
P.B. Baxendell, CBE

COAL AND THE FUTURE ENVIRONMENT
Sir Derek Ezra, MBE

ELECTRICITY AND THE FUTURE ENVIRONMENT
G.A.W. Blackman, CBE

NUCLEAR POWER AND THE ENVIRONMENT
D . Lewis Roberts

ENVIRONMENTAL NOISE CRITERIA
Professor J.B. Large

THE ROLE OF THE LOCAL AUTHORITY IN THE CONTROL OF NOISE
G. Charnley

COMMUNITY RESPONSE TO NOISE
C.R. Cresswell

POLLUTION FROM ROAD VEHICLES
J.H. Boddy, Dr. S.R. Craxford and Dr. A.W.C. Keddie

THE EC DIRECTIVE ON SMOKE AND SULPHUR DIOXIDE:
THE FUTURE FOR SMOKE CONTROL
P. Evans

POLLUTION AND THE COMMUNITY
Frank Haynes, MP

NATIONAL SOCIETY FOR CLEAN AIR

47th ANNUAL CONFERENCE
22 - 25 SEPTEMBER 1980
BOURNEMOUTH

GAS AND THE FUTURE ENVIRONMENT

by

Mr. W.R. Probert
Director of Sales,
British Gas Corporation

National Society for Clean Air
136 North Street
Brighton BN1 1RG
England

INTRODUCTION

The national need for energy is often in conflict with the desire for conservation of the environment. The Gas Industry has for many years recognised a need to reconcile its activities with matters of environmental concern. British Gas operates one of the largest and most complex natural gas transmission systems in the world. It has had to design, construct and commission this system within a very short time scale and within complex town and country planning legislation and at a time when there is a greater interest in environmental matters than ever before.

At the present time British Gas supplies natural gas to some 15 million households, nearly 80% of all households in Great Britain, together with 600,000 industrial and commercial users. The existing supply system from offshore fields, shore terminals, reception stations, transmission feeder mains compressor stations and local distribution systems reflect a care and concern for the environment not only in terms of visual impact, noise control but also engineering standards and public safety.

British Gas will continue to develop the system to meet the growing demand for natural gas, but in such a way as to reconcile the conflicting interests aided by the development of techniques of environmental impact analysis. The maximum contribution which the industry can make to future environmental protection is to ensure maximum use is made of the total transmission and distribution system, virtually unseen and unheard, which represents a major national asset, an investment of over £9,000 million. Furthermore, this system should be used not only during the lifetime of natural gas reserves but beyond - to distribute gas manufactured from a range of feedstocks including coal - substitute natural gas - SNG. Such developments, whilst unlikely before the end of the century, have important environmental implications which must be taken into account in the Gas Industry's forward planning.

This paper attempts to establish the contribution which gas is likely to make to the future energy needs of the nation

and to identify and discuss the vital relationships between and reconciliation of energy supply and environmental concern.

FUTURE ENERGY TRENDS

It is with a considerable degree of caution that one should attempt to make any prediction of the future - but in the field of energy forecasting there are particular problems, as has been graphically demonstrated by global scale crises in the 1970's. The only certainty is that any forecast will be wrong. Nevertheless, there has to be a broadly accepted framework and in the interests of avoiding controversy I have used as a basis for the Gas Industry's contribution to future energy needs the Government's paper on energy projections 1979.

There is reason to believe, from recent surveys in Western Europe, that public hopes and expectation as regards the sources of energy by the year 2000 are vastly different from the projections by energy industries themselves.

In brief, the public would like to see significant and major contributions from renewable 'free' energy sources - the sun and the wind. The public expect, however, that nuclear power is going to make the running. In practice neither scenario is at all likely for many years. The public have been misinformed by doom laden pronouncements on reserves of fossil hydrocarbons or the uneconomic nature of extraction.

The following table is based on data from the 1979 paper showing a possible range of primary energy sources in 1990 and 2000.

By the turn of the century 80% of primary energy needs may well still be met by coal, oil and natural gas. The contributions from coal and oil do not substantially change between 1990 and 2000. The gas share falls, not because of dwindling availability but through a deliberate policy of reserving gas for the higher premium markets during the 1990's, and thus enabling those markets - domestic and

industrial process loads to be supplied further into the future - well into the next century even on the basis of present known reserves.

PRIMARY ENERGY 1990

	(mtce)	% Share
COAL	124-132	34
OIL	125-137	34 - 35
GAS	84 - 88	22 - 23
ELECTRICITY	34 - 35	9

PRIMARY ENERGY 2000

	(mtce)	% Share
COAL	128-165	32-36
OIL	114-132	29
GAS	66 - 69	15-17
ELECTRICITY	88 - 95	21-22

Primary energy analysis does not take into account the conversion of primary into secondary energy and the significant use of energy in transport. A more meaningful analysis is to take forecasts of final energy demand in terms of actual heat supplied - from whatever source - excluding transport.

In terms of heat supplied to industry, commerce and the home we expect gas to have a share of about 25% by 2000. In the domestic market, however, it will be supplying about 65% of our energy needs - probably the maximum it can attain, due allowance being made for non-gas supply areas and energy usage for which gas is unsuited. This compares with a 50% share in 1980.

<u>FINAL ENERGY DEMAND (EXCLUDING TRANSPORT)</u>

<u>1990</u>

	billion therms	% Share
SOLID FUEL	7.8-8.3	13
OIL	23.6-26.1	39-40
GAS	20.4-21.3	32-33
ELECTRICITY	9.0-10.0	15

2000

	billion therms	% Share
SOLID FUEL	14.5-17.1	22-23
OIL	22.1-26.0	34-35
GAS	16.9-18.3	24-26
ELECTRICITY	11.3-12.9	17
CHP	.6- .6	1

It must be emphasised that it is <u>natural</u> gas which is under consideration. Government projections suggest that natural gas supplies may need to be supplemented by substitute natural gas (SNG) - the timing dependent upon the view taken about future reserves. The 1979 Energy Paper concluded that the technology for provision of base load SNG would need to have been determined by 1990. This is a very important matter for environmental interests. Future gas reserves, the potential from as yet unexplored sectors of the continental shelf, could significantly affect future energy usage profiles. Not only is there uncertainty about indigenous reserves - suffice to say that BGC believes there are significant sources not yet discovered - but also about the possibility of supplementing our reserves from the Norwegian sector. Furthermore, the whole picture is constantly changing because of the rising real price of oil which can transform the economics of supply overnight. Earlier this year the Government approved a joint enterprise

to gather natural gas and associated gas liquids from a number of offshore fields by pipeline - a gas gathering pipeline. A similar proposal was considered totally uneconomic only 18 months ago.

GAS INDUSTRY STRATEGY

For the purpose of environmental consideration, however, it is the general pattern of energy usage which is more important than any further speculation. What is beyond dispute is that natural gas will continue to make a significant contribution to national energy needs until well into the next century with the strong possibility, based on proven technical capability, of manufacturing SNG initially to supplement natural gas at periods of peak demand but eventually replacing it. The future environment is going to influence and be influenced by the development of an SNG based industry, but since it will utilise the present pattern of transmission and distribution and utilisation, the only significant change will be at the point of production, i.e. the gas works. Moreover, the timing is so far ahead that this paper must deal primarily with the present Industry's relationships with the environment which are likely to remain substantially unchanged over the next 30-40 years. Since the 1960's when the modern Gas Industry was conceived the contribution to environmental protection has had less to do with atmospheric improvement, although increased utilisation has had a continuing benefit, than the physical and audio-visual implications of developing the transmission system with particular implications for rural areas, whereas gas manufacture and distribution had been an urban phenomenon.

It is the philosophy of British Gas that the comprehensive transmission system, augmented as required according to future demand patterns, should be used to the national benefit as for as long as is practicable. Above all, it is a ready made distribution system for any gaseous fuel which might take over from natural gas. The main components of the system both now and into the future consist of shore terminals, reception stations where gas is treated, liquids separated for use in the chemical industry or power stations,

transmission mains and compressor stations which boost supplies over long distances. The transmission system operates at pressures up to 70 bar (1000 psi) and comprises 5000 km of pipe. Gas is received into local distribution networks operating at pressures up to 7 bar, but mainly less than 75m bar. Whereas the transmission system has been constructed during the last 10-15 years many parts of the distribution system date back to the beginning of this century and some cast iron mains, still in use today, are over 100 years old and are still in good condition. About 50% of the system is now less than 30 years old. The Industry has been pursuing a policy of mains and services renewal for many years. By 1984 it is planned to replace the smaller cast iron mains which are most vulnerable to fracture and which are located where any large scale leakage might cause danger. The programme of renewal will continue so as to ensure that the Industry's most important asset is maintained in good order. Significant savings in maintenance costs and environmental ' disruption' will be achieved as newer materials - polyethylene, ductile iron and steel - begin to predominate.

The gas business is basically the provision of essential heat services, and much of the demand is temperature sensitive - much higher in winter than summer. The load factor of demand - which is an expression of the relationship of the average to peak demand-is lower than the load factor of supply, particularly gas supplied from oil fields where the extraction rate of oil is the determining factor. Gas has therefore to be stored to meet peak demands just as it did at the town gas works. Even though gas usage has grown 6 fold since the 1960's, a smaller number of conventional gas holders are in use because other methods of storage have been adopted which are of major environmental significance. A number of liquefied natural gas storage units have been developed in which gas is compressed to 1/600th of its atmospheric volume. Whilst of great value in the short term, such storage methods are too costly to deal with the greatly increased quantities of peak storage needed in future years. It is therefore an expensive option and not likely to be expanded into the future.

During the early years of natural gas expansion it was necessary to support 'firm' sales made throughout the year, but at low load factor with "interruptible" sales, gas released during periods of interruption then being used to support firm loads. As 'firm' demand grows in the future additional peak supply gas will be needed and this must be provided from bulk storage. Futhermore, it is sensible to adopt a depletion strategy which retains gas supplies for those markets which make best use of the fuel - the premium markets - for the maximum period in the future. Every therm sold in the non-premium interruptible market today is one therm less to be sold for industrial process or in the home at some future date. It is the Gas Industry's policy therefore to phase out interruptible supplies in the future and to utilise bulk storage to meet peak demand.

What at first sight might appear to pose a considerable threat to the environment does in fact prove to be of positive benefit. Having had no success with "natural" geological storage British Gas is now developing a bulk storage facility in leached salt cavities in South Yorkshire.

Perhaps the ultimate in storage will be reinjection of natural gas into depleted offshore fields and to use such structures as seasonal storage. The Rough field, now partly depleted having been supplying gas since 1975, has been bought outright by British Gas for this purpose. Gas originating from the northern part of the North Sea supplied at high load factor at rates surplus to immediate requirements, will for some 9 months of the year be compressed into the structure. Gas can then be extracted in much larger quantities for short periods of peak demand.

Yet a further development is the proposed exploitation of the wholly owned British Gas offshore gas field off the lancashire coast - the Morecambe Bay field. The method and rate of deletion will be determined not by the economics of that field in question, but in such a way as to provide maximum benefit to the system as a whole by using the field as a source of gas only at periods of peak demand. At a later stage the field may be used as a

seasonal store, gas being reinjected through the summer months for eventual use to meet peak demand.

ENVIRONMENTAL CONSIDERATIONS

All these developments are designed to extend the services currently provided by the Gas Industry into the future. It is worthwhile, therefore, looking at the environmental aspects of these developments. There are usually two immediate realities concerned with any new Gas Industry installation. Firstly it will almost inevitably be visible to some degree. Secondly, no one will want to see it, hear it or smell it, and many people will fight for it to go away. This attitude is not unique to the United Kingdom. Throughout the world there is a growing awaremess of the need for the protection of the so-called "natural environment" against industrial activity. In Britain much of this "natural environment" is in fact man-made, but this does not affect the main issue. Proposed installations have to face a series of statutory and non-statutory planning procedures which are probably as complex and comprehensive as in any other part of the world.

Almost everyone in a civilised society wishes to take the fullest possible advantage of the available services offered by public utilities, but few perhaps understandably wish to have the necessary installations on their doorstep, many will fight to try to prevent such development. This phenomenon has been described as the "anywhere but here syndrome" and is characterised by the emergence of local action groups as soon as a project is mooted. Many of them have an impressive track record, and have given rise to extensive literature on the subject of opposition.

The gas Industry is in no better position than any other developer when proposing the use of a green field site for above ground installations, terminals, storage sites, compressor stations, etc. since these are not covered by the powers vested in the Gas Industry by the 1965 and 1972 Gas Acts. In some respects the nationalised industries are in rather a worse position than a private developer. Both have to abide by the Town and Country Planning Act, but in

addition the Gas Industry has to operate within other statutory controls which are sometimes conflicting. Section 2 of the Gas Act states that it is "the duty of the Corporation to develop and maintain an efficient co-ordinated and economic system of gas supply". On the other hand Section 11 of the Countryside Act 1968 (Section 66 of the Countryside (Scotland) Act 1967) states that "in the exercise of their functions every....public body..... shall have regard to the desirability of conserving the natural beauty and amenity of the countryside".

It followed that the most economic and technically efficient solution to the problem may not be acceptable to those authorities responsible for approving a planning application to develop a site.

This dichotomy has influenced British Gas from the outset. Great pains are taken to try to achieve solutions to problems which are acceptable at least to some degree to all parties concerned. Such solutions tend very rarely to be the cheapest, nor are they necessarily the most technically desirable. Consequently a more detailed assessment has to be made in respect of each individual site, so that the optimum choice can be made between economic, technical and amenity options. The Techniques of cost benefit analysis in this field are extremely difficult to apply, as up to now no really satisfactory method has been proposed to place meaningful monetary values on such subjective and emotive issues as the beauty of a Welsh river valley, a Scottish mountain scene or the rolling English countryside.

The United Kingdom is one of the most densely populated areas of the world and the pressure on land usage is very great. Even so, substantial areas are effectively banned to any potential developer, be he an individual looking for a site for a house, or a nationalised industry looking for a site for a large and important project. Many types of land are subject to one form of protection or another and in total, these protected areas add up to some 40% of the total surface of the country. In addition, at least another 10% comprises the built-up areas of towns and cities. Much of the remainder is either upland areas above, say, 800 feet

where development is technically very difficult, or high quality agricultural land whose value to the nation is arguably as important as a gas station. Of the 4,000 to 5,000 miles of coast line, some 60% is protected, and a large proportion of the remainder is already developed, and thus not available for on-shore oil and gas terminals. The technical parameters relating to the latter are also very restrictive and, as an indication of the nature of the problem, it is interesting to note that when the search for a terminal for the Viking gas field was made, only three possible new sites were located between Yarmouth and Easington in Yorkshire in a length of nearly 150 miles of coastline.

In pursuit of the objective of o taining satisfactory planning consents within a reasonable timescale, British Gas has developed an extensive system of investigation, consultation and analysis to produce Environmental Impact Statements and Analysis. The main content of such reports is a detailed justification for the project - why and when it is needed, why the particular site was chosen compared with the alternatives, and a description of the effect the installation is likely to have on the local environment. It has to cover the economic and technical aspects of the project as well as the geographical, social and ecological ones more usually associated with environmental studies. By adopting this system, which sets out to answer as many legitimate questions as possible in a single document at the planning application stage, considerable success in obtaining planning consents has been achieved. During the past ten years consents have been abtained for over fifty significant projects, often in environmentally sensitive areas, in timescales which on average seem to be shorter than those quoted by other organisations. Also this approach has earned British Gas the reputation of being an environmentally responsible organistation.

British Gas has shown that it is possible to obtain planning consents within an acceptable timescale whilst satisfying the reasonable requests for information from local authorities, residents and organisations without the need for any statutory form of environmental impact analysis

as has been suggested in some quarters.

Unnecessary and unreasonable delay brought about by the planning process or indeed any other factor can in our case increase the cost of making a gas supply available and thus distort not only the economy of British Gas but also the economy of the nation as a whole.

LONGER TERM CONSIDERATIONS

In its corporate planning British Gas takes account of the very long term when natural gas supplies may be no longer adequate to meet demand. At present the gas which British Gas supplies to its customers consists almost entirely of natural gas, and 99% of this comes from offshore gas fields which have been discovered within and near to the British sector of the waters surrounding the UK.

In the very long term, supplies of indigenous natural gas will decline and the Industry will need to move to other sources of gas to maintain supplies to premium markets. For example, supplies of gas could be imported by pipeline or by sea tanker in the form of Liquefied Natural Gas (LNG) if they are available on suitable terms. However, based on current estimates, it seems likely that a significant proportion of gas supplies in the long term will be from coal based SNG operating at a high load factor.

The implications for the environment of coal utilisation are clearly a matter for the National Coal Board contribution to this conference, but there will be an important relationship between the coal and gas industries as regards the production of coal based SNG.

The 1978 Green Paper on Energy states that "about the turn of the century, the use of coal in power stations could be falling and coal may be drawn increasingly into other markets, e.g. in industry and for the manufacture of SNG" (para.6.11). It is not yet clear how large a share of the energy market could be won by coal-based SNG but the potential coal requirement is very large. For example, if a market of a size equivalent to the estimated premium

gas market of the 1980's were supplied by coal-based SNG around 100 million tons of coal would be required. The Green Paper shows an SNG market for coal beginning in the mid 1990's and reaching 30 million tons in 2000.

British Gas believes there is a good prospect of further significant discoveries of natural gas to supplement known discoveries. Our central planning assumption is that total available reserves will be higher than the main assumption on natural gas reserves used in the forecasts quoted in the Green Paper. Because of this we do not envisage a need for coal-based SNG until the end of the century, although a start may be made to phase in some production capacity before then. Oil Based SNG for peak shaving purposes could be required in the 1990's.

SUBSTITUTE NATURAL GAS

British gas believes that when the time comes it will be possible to produce SNG in a manner that has a limited effect on the environment. During 1978 the Corporation brought together a long term research, development and demonstration programme on SNG spanning some 20 years and costing several hundred million pounds. The main objective of the programme is to ensure that when the need arises British Gas has the capability of producing SNG from a complete range of fossil feedstocks that may be available. Because of this research work and our links with SNG work done abroad, we have gathered considerable information on the technology of converting coal to gas and on the environmental implications of that process.

It is as yet too early for British Gas to have precise plans for the various sites where SNG may eventually be produced. Because the SNG costing studies to date are design studies, based largely on American conditions and because no large scale plants have not yet been built even in the United States, it is also impossible to give accurate figures for the likely cost of coal-based SNG when it will be required in the UK. The efficiency of currently available SNG plants is around 65% depending on the process route chosen, but future developments, particularly on second generation

plants, should result in efficiencies rising to 70-75%.

The SNG programme will create a requirement for land and a review of our former gas manufacturing sites has been carried out to determine their suitability for SNG production. 25 sites are thought to be potentially suitable locations for SNG plants and are being studied more carefully.

The consideration of national supplies of SNG illustrates a potential problem which might arise out of the present local approach to land use planning. Matters of national significance to energy policy must be considered by Government in total, and it is for consideration whether the local planning process can effectively handle such strategic matters as a future SNG plant of which there might be but 20 serving the whole of the country.

Although British Gas does not believe that SNG will be needed for some time, it is most important that there should be recognition among those concerned with energy policy of the very considerable advantages, both economic and environmental, that SNG possesses compared with using coal direct. Coal can be converted to SNG and distributed to customers at overall efficiencies about double those of electricity generation from coal. The gas can be used efficiently by consumers in gas appliances, thus maximising the value of their existing investment which amounts to around £7,000 million at current replacement costs, of which more than half is accounted for by central heating installations. Put in another way, each domestic customer has, on average, some £500 invested in gas appliances in addition to the Gas Industry's own investment in transmission and distribution which on a current valuation amount to over £9,000 million or over £600 per customer.

Making and distributing SNG will have substantial environmental advantages compared with alternative methods of using coal maintaining the benefits to our cities from the clean combustion characteristics of gas and avoiding pressures on transport systems. The Gas Industry believes that it will eventually be optimal from a national energy

standpoint to supply the premium markets with SNG for use in high efficiency gas appliances rather than deliver coal direct, or indeed convert it into electricity, taking into account both environmental and efficient utilisation considerations.

What then are the environmental implications of SNG from coal? British Gas envisage that a 7 million m^3/day coal based SNG plant would operate at a high load factor (330 days/year) and its annual coal requirements would thus be about 5 million tonnes. During the year 1977/78 231 NCB mines produced 106 million tonnes, a yearly averag of 0.46 million tonnes per mine. Such an SNG plant would thus consume the production of 10-11 "average" mines or about half the expected output of the new Selby coal field Unless nuclear power becomes the main source of electricit generation and the NCB meets its long term coal production targets, it might be necessary to import coal for some SNG plants in the next century.

A typical SNG plant will occupy some 200 to 300 acres and employ a permanent labour force of, say, 500. There would be a four year construction period with a peak labour force of 4,000. The plant would demand substantial quantities o water primarily for use as a feedstock, and a significant power requirement. Suitable precautions would be taken to maintain noise, dust and other atmospheric emissions below limits acceptable to the appropriate authorities. The plant would not resemble traditional coal gas works, but would have similarities to oil refineries and power stations.

The only major environmental impact would be at the point of gasification - the transmission system and utilisation having only minimal environmental effect. Thus this route from coal to usable heat compares well in terms of environmental impact with any other route. At this stage we can identify three positive types of location:

(a) At or near the pithead. Ideally designed into the development plans of the NCB.

(b) At a convenient point on or near to the transmission system to which coal could be bought by rail or sea.

(c) In or near centres of demand, probably using existing gas works' sites.

Production of SNG will have an impact on the environment, but this can be identified and minimised using the techniques of environmental impact analysis.

The timescale British Gas is having to work to with respect to the manufacture of SNG is in the order of 20 years, whereas the process for local authority structure and local plans is only 5-10 years. Local planning authorities will, therefore, find it difficult to accept the implications of the long lead times involved in energy projects. Hence our contention that the land use planning process should have regard to the national energy requirements which should in the end take priority over purely local considerations.

MARKET DEVELOPMENTS

By virtue of its present position in the market British Gas is in a reasonable position to assess the future requirements of the industrial, commercial and domestic markets.

In the industrial sector compared with the direct use of coal there are substantial benefits from using gas from the point of view of transport, storage, handling, controllability and cleanliness. The practical difficulties of the direct use of coal limit the number of industrial processes for which it can be used. In the premium sector, trends in production methods have been towards more automation and more accurate control of heating cycles and temperatures giving higher product quality and fewer rejects. Most premium industrial processes just could not be performed by the direct use of coal and there will be a continuing need to supply the industrial premium market with gas - natural gas or SNG.

In the non-premium sector, the main example of which is steam raising, the quality of the energy input is not so important. As the Green paper says, coal is likely to begin regaining a substantial share of the non-premium market in the future as real oil prices rise and as interruptible gas supplies are phased out.

The extent to which coal takes over this market will be influenced by such considerations as load size and geographical spread. Half of non-premium gas is used in 600 separate establishments, each using less than the equivalent of 40,000 tonnes of coal per year and the majority of them are using less than 8,000 tonnes of coal equivalent. Clearly, there are important implications for storage and road transport. We see a broad balance being established in which premium applications together with some "upgraded" usage influenced to some degree by environmental considerations will remain on gas, the remainder going over to solid fuel.

In the domestic sector, Gas is expected to continue to increase its domestic market share for most of this century. For example, the Green Paper envisaged that the share would grow from 47% in 1978 to about 60% by 1985. It is the largest premium market and the Gas Industry expects to continue supplying it with SNG after natural gas output declines. Solid fuel will continue to be used, particularly in places outside the gas supply area. Apart from these areas, solid fuel use is not likely to increase to any significant degree. Storage space is very restricted; over the past few years the ground area in urban districts has become even more limited. As a result, possible coal storage space has not been built-in to modern houses, let alone flats, and access to suitable places may not be available. Handling solid fuel even with modern fires and boilers is still relatively inconvenient. Any improvements in handling could be expensive in terms of capital and space. The lack of chimneys in many modern houses will also limit the use of coal.

Commercial customers such as office blocks, hotels and schools are often in sites which are affected by many of the

factors discussed above for the domestic market.

One development which has claimed important benefits in terms of both conservation and the environment is combined heat and power generation in association with district heating. District heating on its own manifestly does not save energy, nor does it have any environmental advantage over individual gas systems. CHP, however, can save energy and cannot be ignored. It must, however, be applied selectively after a full economic appraisal, taking all the implications, including important environmental considerations, into account.

The Gas Industry does not in principle oppose the introduction of CHP, but it does consider that the potential role of CHP in the long term should be carefully evaluated by a study of the very real problems of implementation and their effect on the environment.

The timing of the rate of introduction of CHP will depend on other technical development, such as heat pumps, and on the availability and price of gas and oil. In the light of such uncertainties it would be neither realistic nor desirable to set targets on the rate of development of CHP. Further study is needed on the evaluation of traffic and environmental disruption caused by the laying of completely new mains and distribution networks in city centres and the possible reaction of the public. Futhermore, a premature decision could prove to be very wrong in the light of sociological trends involving population and housing patterns and the problem of inner city decay, which has not yet been solved.

We believe that heat pumps run on SNG represent a realistic potential alternative to CHP in the long term. Although currently less well-developed than other options, the SNG heat pump would have theadvantage of very little disruption of the environment and introduction on a gradual basis would allow immediate response to improvements in technology whilst allowing free consumer choice. British Gas firmly believes that the interests and requirements of the customer are best served by individual systems

for domestic space heating. The customer's own control over his choice, operation of and payment for his heating system is an important factor leading to the conservation and economical use of energy.

CONCLUSION

Care for the environment is a policy which is becoming increasingly a public issue and one which governments throughout the world are taking very seriously. Organisations such as ours whose functions will have an impact on the environment will have to learn to live with this policy and co-operate with it. The experience of British Gas has been that by taking a positive action and employing techniques such as environmental impact analysis it is possible to achieve a reputation for being environmentally resonsible. It has also been our experience that the planning system and procedures, as at present operated by local authorities and developer acting in co-operation, enable consents to be obtained without undue delay, thus achieving significant reductions in cost.

The future seems to point to an ever increasing concern for the environment and the need for energy has to be reconciled with that concern. The continued utilisation of Gas would seem to represent an option totally consistent with environmental protection. The track record of British Gas over the past 20 years suggests that industry has come to terms with the environment, and there is no reason to believe that this will not be perpetuated.

Perhaps the most frequent criticism of planners and forecasters is that they all too readily assume the continuation of the past into the future. This paper has attempted to show that at least as far as the Gas Industry is concerned we intend to ensure that the present is extended into the future, both from the point of view of natural gas supply and environmental concern.

NATIONAL SOCIETY FOR CLEAN AIR

47th ANNUAL CONFERENCE
22 - 25 SEPTEMBER 1980
BOURNEMOUTH

OIL AND THE FUTURE ENVIRONMENT

by

P.B. Baxendell, CBE
Chairman, Shell Transport & Trading Ltd.

National Society for Clean Air
136 North Street
Brighton BN1 1RG
England

Introduction

I am glad to have this opportunity to talk to you today, and to discuss the part which oil and gas, and the international oil industry, will be playing in the years ahead. In particular, I shall concentrate on the role of oil in the total energy picture, and the environmental aspects of the use of oil.

Let me begin by stressing the dramatic changes which have taken place in the world energy scene since the oil crisis which followed events in Iran at the end of 1978. These involve not only a near tripling of oil prices but also a fundamental change in attitude of the main oil producing countries. Such changes inevitably affect the oil industry; they also affect the basic interrelation of energy sources through the eighties and nineties and well into the next century.

Whatever predictions you care to believe about the future rate of world economic growth, one thing is certain: it will continue to impose increasing calls upon energy. But the events of the last eighteen months mean that oil, the traditional stalwart of the energy scene, can no longer be relied upon to meet increasing needs. Let me illustrate the scale of the problems with a few numbers. At the end of 1978 or early in 1979, a general consensus of the then current forecasts would have shown non-communist world availability for crude oil in the year 2000 in the range of 65 to 75 m b/d (million barrels a day) (including synthetics). Today, that estimated figure for world availability at the year 2000 has dropped to something in the order of 50 to 55 m b/d. Technical production potential has not changed - the oil is still there. The change stems from uncertainty as to whether some producing countries will be willing to make it available.

So this conference has to consider an energy future considerably different from previous forecasts; it has to recognise that a totally different balance in energy sources will have to be developed, and that this balance may be extremely precarious in the decade immediately ahead of us. In

addition, energy uncertainty has related economic, social and political consequences which affect us all.

I believe that these considerations are basic to your discussions. And as the fundamental changes which triggered them off are so closely the concern of the oil industry, I feel that some elaboration of this theme is required from me.

An understanding of the general energy situation is essential if we are to go on to discuss the way different fuels are utilised, particularly since utilisation has wide-ranging implications for the atmospheric environment. I would like first to discuss the overall energy scene, then to outline developments as I see them and the effect that they are likely to have upon our environment as a whole.

Why must we look ahead?

The problematic state of the energy and economic future as we see it today has roots which span three decades, and which relate fundamentally to the growth of the industrialised world's dependence on oil.

During the post-war years the world used crude oil as a relatively low-cost, readily available power-source for its industrial expansion. In the years between 1950 and 1974, production of oil increased by a factor of 5, while price decreased in real terms. Until 1973, this confident reliance on oil made industrial and economic growth seem like a natural progression. So natural, in fact, that even the oil crisis in 1973 only dented the industrialised world's confidence in its energy security. The supply and price problems which arose at that time gave a sharp shock to everyone from motorist to Minister but as the immediate problems passed, so did the immediate incentive for corrective action, despite the fact that some observers had already foreseen a potentially grave imbalance of oil supply and demand for the early to mid-1980s.

The impact of the 1973/74 oil supply problems was lessened by the ability of the international oil companies to play a 'balancing out' role - or, as we sometimes said at the time,

'to spread the misery'. Today we cannot play the same role. Why? Because that first oil crisis also accelerated change in the structure of the world oil scene. It began with moves towards greater control by governments of the sources of oil production, through participation, or through nationalisation of oil reserves.

In 1970 the major international oil companies had available, by virtue of equity interest, just over 70% of oil production outside North America. By 1979, this had dropped to some 20%. In the past eighteen months the volumes formerly sold by producing countries to major oil companies under long-term contracts have also been drastically curtailed and a high proportion is now being sold in direct government to government deals, and to other less committed participants in the oil market. New participants proliferated at a time of tight and uncertain conditions in the oil markets, and accelerated the 'every man for himself' attitude which prevailed after the disruptions in Iran.

An increasing number of independent buyers in the already competitive chase for supplies sent prices soaring even higher in the 'spot' market; this in turn led some producing governments to place additional premia on their official selling prices. The inherent danger is that as prices increase, the incentive for OPEC countries to produce at high - or even moderate - rates decreases. At present, the world markets have ample supplies of crude oil and products; demand has fallen significantly and oil stocks are high. This, too, indicates the insecurity felt by many over future oil availability.

The major international oil companies are no longer the main mechanism for ensuring adequate satisfaction of oil demand. They can no longer play a stabilising role at a time when a degree of stability is highly desirable.

In the years between 1974 and 1979 over-reliance on OPEC oil was deplored by many, but the necessary firm action to correct it was not taken in time to allow the world to face problems such as were caused by events in Iran without major disruption. Now we see the results: declining economic

performance in the industrialised world as oil price increases bite home; political and social uncertainty resulting from this, and an uneasy awareness of a precarious energy balance. What lies ahead?

Well, one thing is certain. We can no longer depend on the oil producing countries unquestioningly adapting their production levels to the needs of the industrialised world. They will re-assess their policies in terms of the revenues they now feel they need for their own internal development, and in the light of desirable external relationships. It is not the technical capacity of OPEC countries to produce their oil which is the prime problem; it is their willingness to produce - for both social and economic reasons - that is the crucial factor. The effect on world economies of oil supply uncertainty and spiralling oil prices is only too evident at present and will continue to hang over us throughout the next decade.

In today's changed oil world, it is more vital than ever to recognise the necessity for intelligent anticipation and planned forward action. I am not advocating attempts at clairvoyance; but we should certainly avoid the often panic-stricken impulse reactions to disruptive events if we are to build a secure energy future.

Prospects for this decade

On that basis, let us consider the main factors which will affect us in the decade to come - a decade which will, as I have said, be at best a time of energy constraint and lower levels of economic activity. This is inevitable; with the exception of increased coal use in conventional outlets there can be no dramatic increase in the alternatives to OPEC oil during the next ten years, unless there are surprises on the energy conservation front. The lead times for major energy projects - whether liquefied natural gas, coal, tar sands, nuclear or less conventional forms - are generally between seven and ten years, which means that any additional energy supply projects for this decade should already be underway. The energy supply pattern of the 1980s is therefore bound to be constrained, but the long lead times also mean that it is

imperative that we begin thinking, and acting, now to prepare for the 1990s, if we are not to experience energy-related problems for 20 rather than 10 years.

The most important point of reference for the years ahead is the extent to which our industrialised society will depend on the OPEC countries' willingness to produce oil. Their decisions on production will reflect the differing social, political and economic influences prevailing in each individual OPEC country. We are most unlikely to see concerted decisions based on conventional technical or economic factors.

Consuming countries' reactions to energy problems will also be profoundly important: OPEC decisions on production levels are apparently influenced at least in part by consuming countries' efforts to reduce demand and to substitute for oil use. The need to diversify energy sources is being acknowledged by consuming governments, and of course we heard it stressed at the summit meeting in Venice earlier this year. But there are still environmental and social problems involved in many major energy projects which, allied to the long lead times I have already mentioned, could delay action on these projects to a point where they can make no significant impact in the foreseeable future.

Then there is the additional, and perhaps even greater, problem of declining world economic performance during the 1980s. Low growth cuts oil demand which, as I have indicated, is no bad thing. But during a period of low growth it is far more difficult to stimulate the huge investments necessary to finance large-scale energy projects for the longer term. We know that the investment in major projects to produce energy for the 1990s must be decided during the 1980s, but this will be far more difficult at a time when the industrialised economies are in decline.

Our energy equation should also take account of how vulnerable the current world energy scene is to unexpected political or technical upsets, or imposed environmental constraints. An individual incident - as we saw in the localised disturbances of Iran - can have world-wide

effects on energy supply and demand.

So all these factors must be considered, weighed, and their potential effects assessed. The overall picture is not a cheering one, at least in the short-term. But once we have acknowledged and accepted the problems, we can see the challenges which are presented.

The role of oil

Looking ahead as far as the end of the century, I believe we shall inevitably see a shift in world energy balance away from reliance on OPEC oil, although the timing and extent of this change will depend very much on national and international decisions in energy policy. I have indicated some of the problems to be faced along the way, but these must not obscure the fact that oil will continue to provide for the greatest proportion of the world's energy needs - albeit a decreasing proportion. It would be prudent to assume that crude oil supply will level out at around 1990, and continue on a plateau into the 21st century. The sources of oil supply during the next 20 years will change, in the short term in response to OPEC pricing and longer-term as projects to develop alternatives are implemented. Nevertheless, oil could still be supplying almost half the world's energy by 1990 and not far short of that amount at the turn of the century.

At the same time, in the absence of large-scale alternative energy sources, the cost of crude oil will continue to rise, both as a result of OPEC policies on price and supply, and because new oil sources will be more difficult and more costly to find, develop and produce. In other words, oil is becoming so valuable that we must be increasingly selective in usage.

Priorities for oil use

With this vital point in mind, let us consider some of the possible uses of oil in the years to come, and the implications of oil use policies for the environment.

If we are to be selective in our use of crude oil, priorities would be:

* transport fuel for road vehicles and aircraft;
* base material for special products such as lubricants and bitumen and
* feedstock for the chemical industry.

These are the areas in which there is as yet no easy substitute for crude oil, whereas the oil used today in power stations and for industrial heating could technically be replaced by coal, or by nuclear energy. These fuels as well as some of the less conventional energy sources could also substitute in other applications - solar energy in home heating where conditions allow it, for example.

For the oil industry, this means that crude oil refining patterns in the future will increasintly be directed towards what we call the lighter end of the barrel - producing more gasoline, aviation fuel and diesel fuel - as well as special products such as lubricating oils and possibly bitumen. Production of heavy fuel oils and ships' bunkering fuels from the blacker end of the barrel will be minimised as alternatives become available. This certainly has implications for the environment but before I go on to that topic, let us look briefly at the broad picture of oil use, and its various environmental effects.

Environmental impact

The main impact is from the use of oil as fuel. When it is burnt, in furnaces or boilers for example, sulphur dioxide, nitrogen oxides, soot and fly ash are emitted with combustion gases. The use of gasoline or diesel fuels in road vehicles means that lead, lead compounds, unburnt or partly burnt hydrocarbons, carbon monoxide and smoke are emitted from the exhausts of those vehicles.

Do not forget that although refineries are important emission points for combustion gases, only around 6 per cent of petroleum fuels are used by the petroleum industry itself. The industry needs them for production operations, as fuel

for steam generation and heating in refineries, or as fuels for its vehicles. But the remainder is used by customers and the oil industry has no direct responsibility for, or power to control, any pollution they may cause. Nevertheless the oil industry has always been strongly involved, not only in reducing its own emissions, but also in generating proper product specifications, and establishing facilities to manufacture products which meet governmental and other standards on pollution prevention. Governments and local authorities have the biggest role to play in setting up systems to control or reduce air pollution. It is essential to remember, however, that in some cases pollution prevention requires more energy input, so there is a delicate balance to be struck.

In its own operations the oil industry has always been very conscious of fire risk and similar hazards. Many of the measures designed to avoid these dangers - measures such as prevention of oil spills, prevention of light hydrocarbon leakage and evaporation - also protect the environment in general.

No doubt there has sometimes, in some places and in some operations, been cause for complaint against the oil industry on environmental grounds. I would not seek to excuse past mistakes. I do feel, however, that some of the hostile criticism directed at the industry overlooks the fact that in an industrialised world, complete freedom from pollution is a practical impossibility, just as zero risk in any activity is an illusion. I believe the overall record shows that the industry has behaved responsibly and has been concerned to minimise the environmental impact of its operations while still providing the world with the energy it so badly needs.

One illustration of this concern has been the creation of international, inter-company organisations to study potential environmental problems and solutions. They consider oil industry activities and oil product use, and their aim is to generate reliable information which can be considered by governments and supranational organisations concerned with drafting environmental legislation and regulations.

Shell companies are closely involved in many of these groups, including the Oil Companies' International Marine Forum (OCIMF), which deals with pollution problems associated with the transportation of oil by sea; the Oil Companies International Exploration and Production Forum, concerned with exploration and production activities; and one with which many of you may be familiar, the Oil Companies' International Study Group for Conservation of Clean Air and Water in Europe, known as CONCAWE. CONCAWE was set up some 20 years ago to deal with environmental questions arising from oil refining and oil product marketing in Western Europe. Today, it represents about 85 per cent of the total refining capacity in Western Europe. Its main objective is to study environmental conservation topics related to oil processing handling and use.

In the time available to me I cannot possibly cite the many projects in which CONCAWE is concerned. On the clean air side, it has carried out investigations and report on smells from refinery plants, smoke, noise and glare from refinery operations, and the incineration of refinery wastes, as well as aspects of occupational health.

I would, however, like to draw your attention to one of the studies recently completed by CONCAWE, since this relates directly to the expected change in crude oil refining patterns that I mentioned earlier. It deals with the sulphur dioxide emissions which could result from the use of petroleum fuels anticipated in the EEC till the end of the century. The subject is too broad to discuss in detail, but I would like to give you some highlights from the study, which takes account of the fact that the conversion of heavy oil is accompanied by a reduction of compounds containing sulphur and nitrogen. Thus the resulting 'package' of future refinery products will, on average, contain less sulphur and nitrogen.

Growth in total EEC energy consumption has been assumed to be between 1 and 3 per cent per annum for the period 1975-2000. The more likely scenarios show a 1 or 2 per cent growth rate. In the latter cases, CONCAWE anticipates that sulphur dioxide emissions from the combustion of gasoils and

fuel oils (excluding bunkers) will be reduced by between 5.5 million (58%) and 6 million (63%) tonnes per annum over the 25 year period. Sulphur dioxide emissions from coal burning are thought likely to increase over the same period (assuming that the coal to be burnt has a sulphur content of 1%). Nevertheless the study anticipates a net reduction in sulphur dioxide emissions between 1975 and 2000 which would be of the order of between 2.5 million (16%) and 4 million tonnes (24%) per annum. Of course, these estimates are made on 'likely scenarios': we cannot know the future. But it does seem safe to say that future refining patterns indicate fewer environmental problems for the industry.

Another environmental talking point has been the so-called 'greenhouse effect' - the effect on the atmosphere of CO_2 produced from the combustion of fossil fuels. Important as it is to assess the degree and immediacy of the problem, which is the inevitable result of burning carbon, I suggest that more evidence is required before any meaningful conclusion can be reached.

The challenge in environmental matters is surely one of sensible balance. If we in the oil industry are to provide the energy needed for the future, we must be allowed to tread the line between environmental safeguards and unrealistic constraints. Decisions, both by industry and by governments or other authorities, must be based on an informed appraisal of future prospects. This should be helped by the fact that governments and the public are now far more aware of the facts of life, as far as the world's energy future is concerned. The contribution to be made by the oil industry in providing energy should make us less vulnerable to the type of uninformed or politically motivated attacks about environmental matters which we have sometimes suffered in the past. Such attacks have often been the more damaging because public perception of the industry has fallen behind the reality. Bodies like CONCAWE have played a valuable part in presenting the facts and correcting distorted impressions. Through such organisations, and in its own 'housekeeping', the oil industry has demonstrated its willingness to consider the environmental impact of its operations; to study in depth the possible effects of these

activities and, of course, to correct irregularities or malfunctions where these could be harmful.

I believe, therefore, that we can be optimistic about minimising the environmental effects of oil operations in the years ahead. The trends indicated for future industry operations certainly reinforce this optimism. We have a new energy world ahead of us: it may be that T.S. Eliot's 'burnt out ends of smoky days' are past. Other problems in the energy field remain. Nevertheless, I hope that my presentation as a whole has shown you something of what we in the oil industry foresee for the energy future, the problems and the potential solutions, and the environmental impact of industry operations in the years ahead. I can only assess possibilities, but those possibilities are what I have shared with you today.

NATIONAL SOCIETY FOR CLEAN AIR

47th ANNUAL CONFERENCE
22 - 25 SEPTEMBER 1980
BOURNEMOUTH

COAL AND THE FUTURE ENVIRONMENT

by

Sir Derek Ezra
National Coal Board

National Society for Clean Air
136 North Street
Brighton BN1 1RG
England

INTRODUCTION

In any assessment of the future effects of coal on the environment, it is inevitable that judgements will be made with the past record of the coal industry in mind. Few people would be prepared to argue that the production, and use of coal, at least up to the last war, did not have a disastrous effect on the environment. Many people, who do not have first-hand knowledge of the great advances of recent decades in pollution control and the efficient use of coal, may still believe that an increase in coal use would cause serious deterioration in the quality of the air in urban areas. I hope, today, to set these fears to rest by drawing attention to the many advances which have been made towards the mining and use of coal in ways which cause a minimum of disturbance and pollution.

Increased environmental awareness during the post-war years, culminating in the passing of clean air legislation in 1956, 1968 and 1971, has been responsible for a great improvement in the quality of the atmosphere in urban areas. Strict limitation of dark smoke emissions, with a complete ban on smoke in Smoke Control Areas, has been the major instrument, and has effected a reduction of 80% on average of smoke concentrations in urban areas since 1960. Sulphur dioxide concentrations have also decreased by 50% (due largely to application of the tall stack policy) while the regulations on grit and dust emission from industrial chimneys have greatly reduced the nuisance from these sources. It would be fair to say that the appalling smogs of the 1950s, with their heavy death toll, are a thing of the past.

There is little doubt that these measures can be considered to have been cost-effective, and this is largely because the scope for improvement was so great. We have now reached the point where much greater expenditure is likely to result in a much smaller environmental improvement, and therefore proposals for stricter legislation must be considered more carefully to ensure that the value of the benefits which are likely to result exceed the costs which would be required to meet them. A case in point here is the question of whether or not to impose limits on sulphur dioxide emissions. Here,

other countries (rightly or wrongly) claim that emissions in the U.K. are adversely affecting their environment, illustrating the point that pollution recognises no international boundaries.

The likelihood of a steady rise in oil prices relative to those of other fuels, and the uncertain future availability of natural gas supplies, is causing many industries (including the electricity generating industry) to turn increasingly to coal. While it is anticipated that much of the future <u>increase</u> in demand for electricity will be met by nuclear power, it is thought that the demand for coal by industry will continue to rise, reaching about 40 million tonnes per annum by 2000. This is a fourfold increase from its present level. Solid fuel consumption for domestic use is likely to remain steady at between 10 and 15 million tpa, with a tendency for less to be burnt in the more urban areas. Some quite new markets will, however, be emerging as we approach the end of this century. One, which is a revival of an outlet of historic importance, will be from the gas industry, for the manufacture of substitute natural gas; another will be for the manufacture of liquid fuels, and feedstocks for the chemical industry, to replace or supplement production from petroleum. Some concern is naturally being expressed about the environmental effects of these new processes, but it can be stated, quite firmly, that these plants will be designed for (and will be capable of) total containment of the process materials. Effluents to both air and water will be carefully treated and controlled, the largest being those from the power house on site for the supply of steam and electric power for the process. I shall be returning to this subject later.

COAL MINING

What, then, are the environmental effects of coal production and use today? Taking first the production, which can be divided into deep mine and opencast, the effects fall into three broad classes: visual, social and physical.

Visual intrusion on the deep-mined side results from the minehead buildings, rail and road services, and discard

heaps. The National Coal Board now always take expert advice on the siting of buildings, and landscaping of the whole pit surface to reduce visual impact. Modern methods of soil disposal ensure that tip contours are not too steep, and blend in better with the natural landscape than was the case in the past.

SLIDE 1

The tipped material is now thoroughly compacted, which avoids risk of spontaneous combustion with the unsightly and polluting clouds of smoke which were once so common a sight in mining areas. Much of the discard is today sold under the name minestone, and used for road construction, as bulk-fill material or for land reclamation. Upgrading by heat treatment provides aggregate for concrete block manufacture.

SLIDE 2

Social effects fall largely outside the scope of this paper, but it should be commented in this respect that the mining industry has to win coal from the places where it lies, and there has therefore to be some movement of the workforce as older mines are worked out and new ones are opened up. It is general policy to collaborate with local authorities to ensure that the necessary infrastructure for incoming people can be supplied as efficiently as possible.

Physical effects are probably those which are most familiar, and which have often remained to scar the land long after coal seams have been worked out. They present the greatest challenge to the industry, but much is now being done to minimise the effects of the subsidence, aqueous effluents, grit and dust production and noise. Only about 15% of the aqueous effluents is badly enough contaminated to require treatment before discharge; the rest is directed straight to water courses, unless required immediately for industrial use.

The opening up of new coalfields requires a change in use of land, some of which may be good agricultural land. At the

same time, however, land is released from past workings for other uses. During the last ten years, 3,200 hectares of land have been acquired for new mines and ancillary sites; and in the same period 3,000 hectares of former operational land has been returned to non-NCB use. For example, a spoil heap reclamation scheme at Bentinck Colliery in Nottinghamshire (which was recently the subject of a Business and Industry Award for the Environment) has enabled 28 hectares of land to be returned to farming use, when much of it is now sustaining yields of barley significantly greater than the national average. The scheme is continuing, allowing further land to be returned to the farmer as the reclaimed part of the working spoil disposal site expands.

SLIDES 3 AND 4

A further 5,500 hectares of earlier mining dereliction has been transferred to County and District Councils for land reclamation.

Opencast mining presents some special problems because of the large area of land temporarily affected. In all opencast operations there is a strict procedure for ensuring the storage and proper replacement of subsoil and topsoil, to minimise the loss of agricultural productivity. In some instances it is possible during restoration to iincorporate material tipped during earlier mining operations, resulting in a net increase in agricultural land.

COAL USE

The largest present-day use of coal is by combustion for steam or hot water generation, or for general furnace heating. In 1979/80 some 69% of total UK coal production was sold to the electricity industry for power generation; a further substantial amount was used by large industrial users for the same purpose. Other major uses are for coke manufacture (about 9.5% of 1979/80 output) and domestic or commercial heating (a similar percentage).

The most obvious effects on the environment of coal use by combustion are dust, traffic and noise resulting from coal

delivery and stocking and handling on site, the chimney effluents, and the ash left after combustion. Of these, the handling and stocking may be local nuisances, peculiar to specific sites and can usually be reduced to a negligible level by careful planning at new sites. The gaseous and solid residues generally cause the most concern, because many people can still well remember the effects of coal burning in the early fifties before the benefits of the Clean Air legislation were gained.

Two components of the chimney effluents are of particular concern: sulphur dioxide, produced from the 1 to 2% of sulphur normally present in the coal, and solid particulate matter carried in suspension out of the top of the chimney. In the case of open fires burning bituminous coal this particulate matter consists largely of smoke - a cloud of very fine carbonaceous particles resulting from incomplete combustion of the volatile part of the coal. This smoke is highly soiling and is thought to be the primary cause of much of the damage to health resulting from past pollution "episodes". The fairly low concentrations of sulphur dioxide encountered in most urban areas today (generally less than 100 microgrammes per cubic metre annual average) are not now believed to be, in isolation, a threat to health.

Industrial boilers and furnaces do not, unless very badly operated, make significant amounts of smoke, but they do produce some grit and dust which may produce a light plume at the chimney top. The particles are relatively large and settle out due to gravity quite close to the chimney. They do not pose any threat to health, but they can be an annoyance in locality of the emitting plant. Most new coal-fired boiler plant today operates well within the legal emission limits, emitting on average between $\frac{1}{3}$ and $\frac{1}{2}$ of the permitted amounts of grit and dust.

It has been estimated that there are negligible risks to health from the presence of trace elements, including radioactive elements, in particles emitted from power station chimneys. The worst possible additional exposure to ionising radiation that can result to any individual is

only about 1% of the limits for exposure of the public recommended by the International Commission for Radiological Protection.

Ash from both pulverised coal and grate firing has been increasingly used in building and civil engineering operations, chiefly as a load-bearing fill, for manufacture of building blocks and other building materials, and in sintered light-weight aggregates. A great deal more is used for in-filling material, for example in reclaiming disused gravel or clay pits. In some cases, dumping is necessary. Tests have shown that although some leaching of inorganic salts from infilled ash can occur, this effect is generally small and adequate measures can easily be taken to avoid contamination of water supplies.

The use of bituminous coal in domestic fires has, in the past, been the worst cause of air pollution in populated areas. Since the passing of the Clean Air Act of 1956, Smoke Control Areas have been established in which no smoke may be emitted from any chimney unless the smoke results either from burning an authorised (smokeless) fuel, or from burning a non-authorised fuel in an exempted appliance. For domestic use, exempted appliance means those appliances of the smoke reducing type developed by the NCB Coal Research Establishment at Stoke Orchard. In these fires, air is drawn downwards through the bed, and any smoke formed is burned in a secondary combustion chamber at the back. Since they were first introduced, these appliances have been further developed and improved to the point where deliberate maloperation does not give rise to smoke in excess of the permitted amounts.

SLIDE 5

Coal conversion processes currently in operation are limited to coke and smokeless fuels production. Coal conversion operations are carried out largely in plants which were built more than 20 years ago, at a time when air quality was less highly valued than it is today. The plants were not built in such a way as to facilitate pollution control, and although many millions of pounds have been spent on

maintaining and improving the cleanliness of operation, many of these plants are still sources of some environmental concern.

SLIDE 6

By comparison, an example of one of a later generation of smokeless fuel plants, operating on a continuous rather than a batch process, is the Homefire Plant at Coventry. A plume of steam and a faint discharge of fine ash particles from the chimney top are the only indication that the plant is running.

SLIDE 7

FUTURE ENVIRONMENTAL EFFECTS OF THE COAL INDUSTRY

Apart from the new markets for coal, (substitute natural gas production, the possible production of medium calorific value gas for industrial applications, and manufacture of liquid fuels) the NCB are planning for substantial introduction of new technology into existing markets. The field of greatest current interest is the use of fluidised bed combustion for industrial boilers and furnaces, and possibly also, at a later date, for electricity generation in Britain.

In a fluidised bed combustor, the coal burns in a bed of particles of ash, sand or some other inert material. The combustion air is blown through an air-distributing base-plate at a velocity high enough to fluidise the particles. Unless operating with a high excess of air, it is necessary to remove heat from the bed to keep it within the required operating range, 800 to 900°C.

SLIDE 8

Because the bed temperature is low compared with those occurring in most conventional coal-burning plant, it is found to be possible to effect a high degree of sulphur retention by deliberately adding limestone or dolomite to the bed. The stone is a less effective absorber at higher or lower temperatures - it just happens that 800 - 900°C

is the optimum temperature for absorption.

It is not considered likely that this facility for sulphur retention will be widely used (at least in the United Kingdom), because the present tall-stack policy is both cheaper and more environmentally acceptable. If all coal combustors were to use fluidised-beds with limestone addition, the demands for limestone quarrying and the disposal of sulphated waste stone would be environmentally unacceptable. There may well be individual cases where some control on sulphur dioxide emissions is desirable for various reasons, and here the ability to retain sulphur by limestone addition may be useful.

The nature of the fluidised bed combustion system favours elutriation of solid particles from the bed. Somewhat more expensive gas cleaning equipment will probably be necessary to ensure the same level of particulate emission as is being attained with present-day stoker-fired plant. The likely level of nitrogen oxide emissions from fluidised-bed fired boilers is uncertain, because the factors governing the emission are not completely understood. It is known, however, that when operated at 6 atmospheres pressure, nitrogen oxide emissions are much lower than those from pulverised coal-fired boilers.

Operation under pressure is particularly attractive for electricity generation, because it offers the possibility of combined cycle generation leading to a higher overall conversion of the energy content of coal to electricity. As well as the conventional steam turbine cycle, the hot, pressurised gases leaving the combustor can, after cleaning, be used to drive a gas turbine. Development of this process has been in progress in the United Kingdom for many years at the Coal Utilisation Research Laboratory of the NCB in Leatherhead, and larger scale studies will be made at the International Energy Agency research plant at Grimethorpe in Yorkshire.

Increased efficiency of energy conversion in coal use is beneficial both economically and environmentally, because the disturbance associated with coal production and transport

is reduced for a given energy output.

Another new technology that offers a potential gain in efficiency is combined heat and power, where the heat which would otherwise be dissipated in cooling towers is used instead for space heating. The recent Marshall Report urged that two towns be selected for pilot schemes in order that the problems involved may more thoroughly be studied.

NEW USES FOR COAL

The British Gas Corporation's Study of a process for the conversion of coal to substitute natural gas using a slagging Lurgi gasifier followed by gas re-forming, has included a very thorough appraisal of environmental effects during construction and in subsequent operation of the plant. The plants would make some demands on local water supplies, and treatment of aqueous effluents would be necessary before they could be discharged to water courses. In manufacture of a domestic gas supply, removal of the sulphur and nitrogen content of the fuel would also be necessary. These would be recovered respectively as the element, and as ammonia. Atmospheric pollution would not be expected to be a serious problem, but care would have to be taken in the design of coal handling plant to avoid the risk of dust dispersion. The main solid residue for disposal will be slag, for which there is likely to be a demand from other industries.

Many of the environmental problems encountered in gasification will also be met in the production of liquid fuels from coal, and I shall now discuss these in more detail. Two processes are being studied by the NCB with a view to testing them at a 25 ton/day pilot plant scale. Although broadly similar these processes differ in the nature of the solvent used to extract the organic fraction of the coal, and in the distribution of compounds in the final products. Hydrogen is needed to increase the hydrogen:carbon ratio to that necessary for liquid fuels, and this would be made by gasification on site. The next slide shows in diagrammatic form the liquid solvent extraction process.

SLIDE 9

Siting of the full-scale plant is the first consideration, and the choice will probably rest between a site adjacent to a colliery expected to remain in production for a long time, and one close to an existing oil refinery, where expertise and facilities will be available for the cracking and refining steps to produce a range of saleable products. If the choice is the latter, coal may have to be brought by rail some distance from the point of production, on a scale comparable to that required by a larger power station.

The sulphur in the coal is mostly evolved with the off-gases from the extraction and other stages, where it appears as hydrogen sulphide. One of several available processes for acid gas removal would be used to remove hydrogen sulphide from these off-gases, and from the foul gases resulting from sour water stripping. Recovery of the sulphur would be as elemental sulphur or as sulphuric acid if there were a demand locally for this chemical.

Sulphur production from operation of the plant on a British coal of average sulphur content would be about 30,000 tonnes a year in the absence of boiler flue gas desulphurisation (FGD), or 34,000 tonnes a year if a regenerable FGD system were applied on the boiler flue gases. In the absence of any measures to remove sulphur oxides from the boiler flue gases, about 7500 tonnes of SO_2 would be emitted annually. for comparison, the emission from a power station with a similar annual coal input is over 100,000 tonnes a year. Other boiler plant emissions can be controlled by techniques currently available, or being developed as, for example, combustion modifications for NO_x reduction.

An important environmental aspect is the water demand for the plant and the disposal of waste water from the process.

Water will be required at various places in the process: make-up boiler water to replace steam used in the gasifier, shift conversion and sour-water stripping; and as an input in the gas/liquid separation stage of the extraction plant where it will dissolve ammonia and hydrogen chloride. The contaminated water will join the waste water from the gasification plant which will contain dissolved and

suspended solids together with a mixture of organic compounds including phenols and tars.

The combined foul water will be treated by steam-stripping, with recovery of ammonia and phenols; sedimentation, biological purification, filtration, and if required, by ion-exchange demineralisation and activated-carbon treatment. The demands for cooling water, largely for steam condensers in the electricity plant, will almost certainly exceed the foul water flow rate, and a very high standard of purification will not normally be called for to give water of a quality suitable for cooling. Much of the water used for cooling is lost by evaporation, and this greatly reduces the volume entering the final treatment stage.

Combustion-derived particulates emission will be subject to a limit agreed with the Alkali Inspectorate, with whom the plant will be required to be registered. The limit will probably be in line with that applied to other large coal-fired power plant; this is currently 115mg per cubic metre of dry gas measured at 288 degrees Kelvin (about 15 degrees Celsius). This corresponds to an emission of just under a kilogramme of ash for each tonne of coal burnt.

The emission of fine coal particles from the coal drying and grinding processes is one of the problems encountered at present in the operation of smokeless fuel and other coal conversion plant. The method of control generally used is a single-stage electrostatic precipitator, which collects over 95% of the dust entering it and reduces the emission to about 200 grammes for each tonne of coal processed.

However, in a new plant of the size contemplated for liquid fuels production it will probably be desirable to aim at a still lower emission rate from the coal dryers, and this could be done by using two-stage or three-stage electrostatic precipitators, or alternatively, afterburners.

Dust from the coal storage area may be minimised by the use of shelter-fences or tree screens to reduce wind velocities, by spraying stockpiles with emulsions of a surface binder,

and by good house-keeping generally, including regular sweeping of roadways and working areas. Fugitive dust from coal transport will be reduced by careful design of conveyor systems, particularly in respect of the hooding of transfer and discharge points.

NATURE OF THE PRODUCTS

Some concern exists that the liquid fuel produced by the degradation and hydrogeneration of coal may be more physiologically active than those made from natural crude oil and may therefore present a health hazard to process workers and people handling the products. Little definite information exists on this question, but it is a fact that the aromatic and cyclic hydrocarbon contents of the coal-derived fuels are higher - about 75% compared with 35% in petroleum. Measurements of the benzo(a)Pyrene content of a sample of the crude product of a degradation coal liquefaction process showed only 50 ppm, which is much closer to that of petroleum (30 ppm) than to that of coal tar (2,000 to 20,000 ppm). Benzo(a)pyrene is often taken as an indicator of the group of poly-nuclear aromatic hydrocarbons that possess carcinogenic activity. It is planned to study the health and safety requirements of coal liquefaction processes in parallel with the development to a full-scale plant.

CONCLUSIONS

(i) Environmental disturbance arising from the mining and use of coal is now considerably less significant than was the case in the period until twenty years ago;

(ii) the total quantity of coal used for power generation and domestic and commercial heating is unlikely significantly to change over the next twenty years;

(iii) the quantity of coal used in industry is expected approximately to quadruple by 2000;

(iv) the environmental effect of increased coal use in

industry will not be as serious as is sometimes feared. Increases in smoke concentrations in urban areas will be very small, and will be counteracted by a decrease in smoke from domestic premises in gas-connected areas. Although sulphur dioxide concentrations may increase somewhat in industrial areas, the levels attained are not expected to present any significant health hazard;

(v) new processes for the gasification and liquefaction of coal will be designed and constructed to reduce pollution to almost negligible levels, and the products will be clean fuels;

(vi) trace elements, including radioactive materials, released into the environment from the use of coal have been shown not to represent a significant possible health hazard.

NATIONAL SOCIETY FOR CLEAN AIR

47th ANNUAL CONFERENCE
22 - 25 SEPTEMBER 1980
BOURNEMOUTH

ELECTRICITY AND THE FUTURE ENVIRONMENT

by

G.A.W. Blackman, CBE
Board Member,
Central Electricity Generating Board

National Society for Clean Air
136 North Street
Brighton BN1 1RG
England

INTRODUCTION

Last year fuel equivalent to more than 100 million tonnes of coal was used to produce electricity in power stations belonging to the Central Electricity Generating Board (CEGB). The one hundred and eight million tonnes was comprised mainly of coal itself (80 Mt). Oil fuel still comprised a substantial part (18 Mtce) while nuclear power (10 Mtce) and other sources provided the remainder. The economics of electricity production is strongly influenced by the costs of the various primary fuels and these relative costs in turn help to define the types of power stations to be constructed. The recent dramatic changes in the costs and availability of oil fuels has had significant effects on all UK industries including the electricity supply industry. The industry has had to think very carefully about the way in which it wishes to proceed in the future and to examine very carefully the various options open to it. Environmental effects are part of this examination. It is therefore particularly pertinent at this time to review the ways in which the electricity supply industry might progress and discuss the environmental consequences. This is true for all environmental aspects, air, water and noise pollution, safety and visual amenity etc. but this paper will deal particularly with those environmental aspects of special interest to the National Society for Clean Air.

On its formation (in 1957) the CEGB was charged with three main duties (1):

(i) To provide an adequate supply of electricity. This implies that the supply should meet the demand made by industry and the public and that the supply should be reliable.

(ii) To do so economically. Failure to provide power, heat and light at a reasonable cost can act to the detriment of the less able elements of our society. It can also prejudice the ability of our industry to compete in international markets.

(iii) To do so in a way which takes due regard of the environmental consequences.

It is this final duty which is the main concern of this paper but in actuality all three are so tightly bound that it is very difficult to separate them. Any new developments in the electricity supply system have to be closely considered from the points of view of economics, reliability of supply and the environment. In the same way, new developments in environmental control or legislation have to be examined from the same points of view. It is these three aspects which summarise the responsibility of the electricity supply industry to its customers, the general public and the environment. The actual details of these statutory duties may change but the responsibility will remain.

PAST EXPERIENCE AND CURRENT PROBLEMS

How has this responsibility been realised in the past, in the field of air pollution? Since 1957 all fossil fuelled CEGB power stations have had air pollution surveys carried out around them during the time that they entered service. These surveys measured levels of sulphur dioxide, smoke and solid particulate matter before the station began operation and afterwards. The measurements were treated to a variety of sensitive analysis techniques and the results have been published (2). They show clearly that the effect of the power stations on the daily SO_2 values in the stations neighbourhood was undetectable against the normal fluctuations in background level. At one particular site the background SO_2 levels were particularly low but the fluctuations in the level were of sufficient magnitude that only an addition of 7 ugm^{-3} or more from the power station would have been detectable. The power station's contribution must therefore have been less than this amount.

The inability of the routine surveys to detect the power station's contribution lies in the statistical variations of the day to day measurements. To overcome this it is necessary to adopt far more sophisticated measuring equipment capable of looking at the variation of air pollution over very short timescales, usually three minutes or less. Several research surveys have been carried out by the CEGB to accomplish this (3), (4). In addition these research surveys have also enabled theoretical models of plume rise

and dispersion to be developed (5).

One of these research surveys was carried out around Eggborough, a 2000 MW coal fired power station in Yorkshire. The results (6) showed that occasionally the power station gives high levels of sulphur dioxide which last only for a very short time. In the long term the power station contributed about 2.5 ugm^{-3} to the average annual SO_2 ground level concentration in its vicinity. This result conforms well with the upper limit of 7 ugm^{-3} given by the routine surveys and can be taken as typical of a large modern power station.

The addition of the power station to SO_2 ground level concentrations has to be judged against the prevailing levels. The annual average in the UK is about 60 ugm^{-3} and this reflects a range of over 120 ugm^{-3} inside city centres and perhaps 20-30 ugm^{-3} in remote rural areas. SO_2 levels have gradually fallen over the years from an average value of over 150 ugm^{-3} in 1960 to the present level of about 60 ugm^{-3}. In the same time the emissions from power stations and other tall stacks has increased from 2.2 to 3.2 million tonnes. This is proof of the ability of tall chimneys to protect the local atmospheric environment.

The only serious challenge to the tall stack policy has been the question of the long range drift of air pollutants. This challenge has been used to reinforce the demands, from some quarters, for an overall reduction in the emission of air pollutants and the consequent imposition of flue gas desulphurisation techniques. Sulphur dioxide is emitted from many types of sources throughout Europe. It is distributed across the continent by air movements and reaches the ground by wet or dry deposition. For nearly all countries this deposition of sulphate is not a problem. The nature of their soils and waterways is such that the sulphate can be readily assimilated and utilised as an essential plant nutrient. Parts of Scandinavia, however, have special soil and water conditions which cannot readily assimilate the sulphate. The Norwegians are particularly concerned that this inability may give rise to increased acidity of a few of their southern-most waterways to the detriment of the fish population.

Those who claim that sulphur dioxide is causing damage on an international scale usually assume a casual connection between distant SO_2 emissions and the acidification of rain and consequent damage to forests, rivers and lakes including a loss of fish populations. The relationship is presented as being proven and as if the situation were getting worse, year by year. Much research is however under way in the world and is perhaps most advanced in Europe. This research has shown that there are a number of fundamental uncertainties about acid rain which raise serious doubts on the above claims. These uncertainties are set out below, but the following conclusion is already clear. The effects of the long range transport of air pollution lie in the tendency to cause an acidification of rainfall above that caused by gases naturally present in the atmosphere. This acidification has no effect on human health and there is no unequivocal evidence of damage being caused to forests. The only possible adverse effect which remains is the indication of a trend of acidification in some upland lakes located in areas made particularly sensitive by a combination of circumstances. In these few areas geology, heavy rainfall, low calcium and acidity may have led to loss of fish population in some cases.

There are very few consistent, long term sets of reliable rain chemistry data against which trends in rain acidity can be judged. In northern Europe the European Air Chemistry Network (EACN) was established in 1955. The sites are widely scattered and have operated sporadically but some have given continuous records for 20 years. American monitoring does not match this time span but there has been a single set of continuous records from 1963 at Hubbard Brook, New Hampshire (7). These rainfall samples are collected monthly. The readings are generally uncorrected for chemical changes brought about by evaporation, dust deposition, chemical reaction and bio-chemical contamination. The EACN experience has shown that these and other factors can introduce errors of 50% or more in some of the measured rain components.

The EACN results show two main features (8). Firstly, there are very wide variations in the annual acidity records, by

factors as great as 4 to 1 in consecutive years. Secondly the trend in acidity prior to the mid-1960s was approximately level and perhaps slightly downwards. The trend from 1965 onwards is exactly the same. There is however a marked and abrupt upward step change in the mid-1960s. If this is accepted as a genuine feature in the measurements, then the smoothed trend over 20 years is an increase in acidity of about 10% per annum. It is far more likely however that this step change can be accounted for by changes in the rainfall sampling and analysis methods introduced in the 1960s. If this is so then there has been no adverse trend in rainfall acidity in Europe. There has certainly been no change since 1965, during which time European SO_2 emissions have increased by 35%. Similarly in America the Hubbard Brook results show no trend in rainfall acidity from 1964 to 1974.

Trends in excess sulphate at the EACN sites show an identical pattern to the rainfall (9). Since 1965 the trend has been downwards. At Hubbard Brook there has been a small downward trend over the same period and possibly for longer. Recent publications (8) of rainfall acidity contours showing an upward trend have generally been based on very sparse data from two isolated years. This practice is highly dubious in view of the wide year to year variations. Some of these contours are not based on measured acidity but on that calculated from other chemical measurements, a practice full of uncertainties and possible sources of error.

Models of long range transport have been developed by OECD and others (10). The models are simple and will continue to be refined. They have however shown, firstly, that long range transport is a function of total emissions and that height of emission is of minor importance; secondly, that the use of tall stacks does not preserve the local environment at the expense of that further away since for a given chimney height, total deposition is always greatest nearer to the source area; thirdly, that the areas most affected do not receive most sulphur, but that other areas receive more and cope with it adequately.

Pure water precipitation in equilibrium with the carbon dioxide of the atmosphere will attain the mildly acidic

level of pH 5.6. The additional absorption of oxides of sulphur (SO_2) and nitrogen (NO_x) will reduce the pH, i.e. increase the acidity. This process is self-restricting, absorption ceases at an equilibrium pH level dependent on the SO_2/NO_x concentrations and other factors. In some regions hydrogen chloride (HCl) from industrial emissions adds to the acidity while other pollutants such as ammonia and calcium can reduce it. These components and reactions are competitive, the absorption of one acid gas will prevent the absorption of others. A reduction in one pollutant may not yield a corresponding reduction in acidity since the rain may then absorb more of another acidifying pollutant.

In the Hubbard Brook studies there was a highly significant correlation between the annual nitrate inputs to the study area and the acidity. There was no significant correlation between rainfall acidity and sulphate input. In Norway nitrates accounted for about one third of the measured acidity and a much higher proportion during short rainfall episodes. It has been reported that precipitation acidity in the Adirondack Mountains may already be due as much to nitric acid as sulphuric acid (11).

Rain percolating through vegetation and soil can acquire acidity both by processes of ion-exchange and by the leaching out of natural acids from decomposing humus. The latter acids can at times represent an important fraction of the total acidity in the rivers. These reactions mean that the composition of lake and river water may bear little resemblance to that of the rainfall. A significant relationship between sulphate and acidity has however been demonstrated for a group of lakes in Southern Norway (12). For these lakes only a quarter of the sulphate is balanced by hydrogen ion. If the sulphate/acidity relationship of these lakes is taken to represent possible changes with time (a doubtful supposition), then a reduction in lake sulphate by 50% increases the pH value by only 0.2 units.

Fish populations in rivers in Southern Norway have been declining since 1890. About half the fish had gone by 1920. Disease, industrial activity and fishery management can all affect stocks (13). Unrestricted netting of game fish has

only recently been brought under legislative control in Norway, after protests by the angling fraternity that over-fishing had dangerously reduced stocks. Acid rain cannot therefore be singled out as the cause of decline in fish populations in some Norwegian rivers.

Trends in fish stocks in Norwegian lakes have been determined by interview and questionnaire and are not based on scientific measurement. They have been compared with spot measurements of acidity and a causal connection drawn. It has however proved difficult to obtain reliable older measurements of pH in the waters that show unequivocally that an acidification has taken place. Isolated individual measurements made during summer are of limited value in this respect. The causal connection suggested is at variance with known data. In Lake Langtjern, for instance, it has been stated that the natural fish population was lost in the 1960s due to acid precipitation. A study of diatoms in the lake sediments has however shown that the acidity of the water has varied around its present level for many centuries and the lowest acidity occurred about 800 years ago (14). The lake has been successfully restocked with trout.

Research into the effects of acid rain on forests has produced no unequivocal proof of damage (15). Field experiments using simulated acid rain have shown no decrease in growth and one type of tree increased its growth rate due to the effect of additional water and nitrate on the nutrient deficient soil. Increased exhaustion of nutrient levels in soils over a long time scale, due to the effects of acid rain, remains an open question.

The situation is obviously very complex and there are many uncertainties and inconsistencies which need to be cleared up. Research is under way in many countries and on many aspects. This research should be encouraged. The recently signed UNECE Convention and Resolution on Long Range Transboundary Air Pollution should assist an international co-ordination of research and assessment of results. It is premature to conclude that the long range transport of SO_2 has been proved responsible for the acidification effects now being studied but some questions still remain open. In the

next few years the effects of acid rain will undoubtedly be made clearer. The time has not yet arrived for legislation on this subject to be advanced with any degree of confidence.

Only if it can be proved that pollutants transported over long distances play an important part in the decline of fish stocks in Scandinavia will it be necessary to consider reduction of pollution at source. Even then such a solution will have to be shown to be economical compared with other possible solutions and will have to be directed towards all emitters regardless of their height of emission. Flue gas desulphurisation (FGD) cannot be the complete answer to this problem. It will still be necessary to ensure adequately low levels of pollutants at ground level in the near vicinity of the power plant. To achieve this a dilution factor of 1,000,000 is required. Present desulphurisation plants can only achieve reduction factors of 10. Thus even with a desulphurisation plant a tall stack will still be required.

The extra cost involved in flue gas desulphurisation would have to be passed on to the consumer and it would amount in an increase in the cost of generating electricity of about 25-30% at those stations employing FGD. There is an environmental cost to be paid too. Chemical reagents such as limestone have to be quarried, crushed and transported to the site in huge quantities. The systems require large volumes of water to wash the gases. The output from the desulphurisation process must be disposed of and if limestone washing were employed then each year a volume of wastes equivalent to over half of that of the ash produced at a coal fired station would have to be dumped somewhere on the land. The FGD systems also need power to run and by themselves reduce the overal efficiency of the electricity generating process. The resulting cost is an energy cost and amounts to between 5 and 10 per cent of the coal burnt at the power station.

A story similar to that of sulphur dioxide can be told for particulate matter. There is however one major difference. The sulphur dioxide can be adequately dispersed by the use of a large chimney but the mass of dust produced from the coal (about 16%) is so large that no chimney could adequately cope.

Instead the dust is removed from the flue gas by very high efficiency electrostatic precipitators. The Alkali Inspectorate has set an emission limit standard on total particulate matter of 115 mgm^{-3} for new power stations (16). At Drax, a 4000 MW power station now being completed in Yorkshire, precipitators with a removal efficiency of 99.5% have been specified in order to be able to meet the emission standard.

The routine air pollution measurements usually measured dust deposition on a monthly basis. Once again, just as with SO_2, no effect on local dust fall levels could be demonstrated due to the introduction into service of a power station. Further research has shown however that in order to define the actual levels of dust pollution from the station much more sophisticated equipment, and analysis techniques, are required. Where these have been deployed the results indicate that modern power stations, in rural areas, are contributing perhaps ten per cent to the local dustfall levels in their area. However this figure has not yet been precisely defined and to do so may require the development of new methods of dust fall measurement. This is an area which the CEGB is actively researching.

One concern expressed more frequently these days is not about the total mass of dust but about its chemical composition. The fossil fuels burned in power stations contain all the known elements, if only in a very small concentration. During combustion some of these elements are volatilised and escape as gas, some recondense onto ash particles and the amount of recondensation may vary according to the ash particle size, others may form organic compounds and some of these compounds may be known to be harmful to health or even carcinogenic.

The CEGB has recently carried out a major survey of these trace elements around Drax power station (17). Where standard particulate samplers were used, it was not found possible to identify any component of trace elements in the deposition samples that could be related specifically to power station operation. The relative proportions of trace elements in the samples were similar to those found in other parts of the country, where power stations are not located.

When directionally sensitive air samplers were employed and aligned on the power station some evidence of the power stations effect could be detected. However, none of the trace element concentrations measured in the locality were significant in relation to public health. This work is currently being extended to check the results over a longer period.

These measurements have been supported by theoretical calculations based on actual measurements of the concentrations of trace elements in particulate matter in power station flue gas (18). The calculations show that the concentrations of trace elements arising from a large modern power station are, at ground level where people will be affected, well below (by factors of between 100 and 10,000) the various air quality standards for trace elements which have been set throughout the world.

One particular class of trace elements of interest is the radioactive species. These occur naturally in coal within the range of concentrations found in other crustal rocks and soils. Like the other trace elements they may remain within the ash collected in the electrostatic precipitators or emitted with the chimney exhaust gases. The local population may be exposed to these elements in a variety of ways but the main route appears to be via the food chain. Recent calculations by the CEGB (19) show that a large coal fired power station probably gives a maximum increase in local exposure of about 6 millirems per year or about six per cent of that due to natural background radiation. The background varies by much more than this percentage between different parts of the UK. The maximum calculated exposure is only about one per cent of the limits for exposure of the public recommended by the International Commission for Radiological Protection and is therefore very safe.

There is a similarity to be drawn here with nuclear power stations. These too are operated in such a way that the maximum exposure is small compared with background. The major conclusion to be drawn is that both systems, nuclear and coal fired, can be operated safely. This conclusion is no accident because the development of both systems is a

very carefully controlled process. In both cases the designs are thoroughly checked by government agencies before the authority to construct is given. In both cases the operatio has to be strictly controlled within limits laid down by the authorising government departments. Much is made of the licensing procedures required for nuclear power stations and rightly so. The checks on coal fired power stations are however no less stringent and in the case of air pollution are administered by the Health and Safety Executive's Alkali and Clean Air Inspectorate.

In the science of environmental protection each field, fossil and nuclear, has learned from the other. One aspect of nuclear safety work now spreading to fossil fuel combustion is that of risk analysis (20). In this area nuclear scientists have learned a lot. They have learned that the relevance of data to the country and power generation system in question has to be clearly established and sources of information quoted. Borrowing statistics from one country and applying it to another is not adequate when national generating systems and safety practices can differ significantly. They have learned the need to indicate uncertainty margins and thereby to establish whether or not meaningful comparisons can be made. They have also found the necessity of making clear whether the risks quoted have been averaged over the whole fuel cycle or relate only to one part of it. It has become clear to them that risks have to be projected forward to the time when new plant will actually be in operation and these risks have to be balanced against the benefits given to society by the system in question. Relative risk data must be quoted with reference to absolute safety levels if it is not to be misleading. If the absolute levels are omitted then the degree of safety achieved is obscurbed and the public unnecessarily alarmed.

If the risks inherent in the use of different types of fuel are to be compared then it is vital that common standards of analysis are applied. This has not always been the case and the lessons referred to above have in some instances been ignored. This has occasionally been done by those who wish to argue an increased use of one particular type of fuel against another, people who should know better. The CEGB

is beginning to explore the application of risk analysis to fossil fuels and will ensure that the lessons learned in the nuclear field are not wasted. The prime concern of the CEGB is to ensure that, whatever fuel is used, the CEGB's power stations can be operated in a safe manner. To play one fuel against another for political gain is mischievous and will only unduly alarm the public.

FUTURE DEVELOPMENTS

The CEGB runs an integrated electricity supply system. The operation of power stations is managed so that the whole system generates electricity in the most economical manner and the price of the basic fuels plays an important part in determining the management strategy. The amount of the different primary fuels converted to electricity has been referred to above. In general, nuclear power stations and the more efficient modern coal fired stations provide the continuous or "base load" supply of electricity. The less efficient coal stations and oil fired units provide a load following capability which fills in the day to day variations of electricity demand. Gas turbines, which burn distillate fuel oil, are very expensive to run and are used to cope with any sudden surges in demand that may arise. Large scale pumped storage is being added to the system to assist in this function at a much reduced cost.

The CEGB's system is therefore based on a wide variety of fuels and contains a capability to respond flexibly to relative changes in fuel price. This is likely to continue for many years as plant is only retired from service when it becomes old and uneconomic. In view of the current price of residual oil fuel and a decreasing world wide availability of oil, it is unlikely that any new oil fired steam power stations, beyond those already under construction, will be commissioned by the CEGB. Gas turbine stations will only be required should there be an increased need to cope with sudden variations of load or a very sudden and unforeseen increase in total electricity demand.

The growth in electricity demand from now until the end of the century is likely to be much less than that experienced

in the 1960s and more akin (though hopefully less erratic) to that of the 1970s. By the turn of the century fuel burn should approach the equivalent of 120 million tonnes of coal. Oil fired plant will still provide some of this generation but the majority will be provided by coal or nuclear power stations. The CEGB considers that the economic argument is so strongly in favour of nuclear generation that future developments must be based mainly on this source of fuel. A small number of coal fired power stations may still be required however for special reasons such as meeting local demand where nuclear power is not practicable.

The government, having recognised the overwhelming case for nuclear power and the need to maintain a viable industry, has announced, for planning purposes, a steady programme of 15 GW of nuclear plant spread over 10 years beginning in 1982. The CEGB will however wish to maintain a large coal fired capability by refurbishment of its major high merit plant and will retain the option to add to this if economically justified or should the maximum practical construction rate of nuclear stations prove to be inadequate in the face of unexpectedly high load growth or unscheduled plant closure. In addition, there may be a longer term requirement for installing flexible fossil units to meet demand growth economically as the proportion of nuclear plant on the system increases. These factors suggest that while the future level of coal burn in power stations is uncertain by the year 2000 it should lie between 60 and 80 Mt per year. This upper level is similar to that of today and levels in excess of 60 Mt have been burned in power stations since 1960. This has been accomplished, as the above review has shown, with a minimal impact on air pollution levels in this country. The CEGB will continue to seek ways to improve its performance in the environmental field provided that such improvements are practicable, but past performance strongly suggests that at least until the end of this century no need can be demonstrated for a stringent increase in the air pollution controls imposed on fossil fuelled power stations.

The ways in which fuels are burned in power stations are also subject to continual development as are the means employed to abate pollution. In many cases the two go hand in hand.

Flue gas desulphurisation has been discussed above and shown to be impracticable and uneconomic. The CEGB has also looked at other ways of reducing sulphur emissions. While the CEGB takes a high proportion of NCB total output there is virtually no scope for reducing SO_2 emissions from coal fired power stations by the selection of low sulphur coals. While this scope may increase in future as NCB production rises, it will be at the expense of other coal users. This may not result in a net benefit to air pollution if smaller boilers with low chimneys were forced to use the comparatively higher sulphur coals.

There are possibilities for a modest reduction in SO_2 emission (up to 20-25%), either by extending current coal washing techniques or by optimising washing plant to remove pyrites from high sulphur coals. Such plant however will give rise to some significant environmental problems over the disposal of high sulphur wastes from the coal preparation plants. Further studies are required to evaluate the technical feasibility and costs of such systems. They are likely to prove more cost effective than other routes such as full desulphurisation of flue gases. The costs however are still very large and until a need has been demonstrated for the reduction of sulphur at source the use of such systems must be regarded as economically and possibly technically, impracticable.

There is considerable interest worldwide in other plant developments such as fluidised bed combustion and coal gasification and liquefaction. The reduction of SO_2 emissions is not inherent in these developments. They can however be engineered to achieve such a reduction, although usually at the expense of a discharge to some other section of the environment.

In the absence of any need to remove sulphur, fluidised bed combustion plant is unlikely to have any material advantage over conventional boilers at unit sizes of interest to the CEGB. Additionally, since the top temperature in the thermodynamic cycle is dictated by the fact that the fluidised bed must operate at a temperature of about 850-900°C so as to be below the ash fusion temperature of

British coals, this limits the thermodynamic efficiency of the cycle. Because of this temperature limitation, the pressurised version, which incorporates a combined gas turbine/steam turbine cycle, will not be able to benefit from the developments in gas turbine inlet temperature which are currently forecast.

If sulphur emission were to be a requirement the injection of limestone into the atmospheric fluidised bed, or dolomite into a pressurised bed, will allow the removal of sulphur during the combustion process although this has not yet been demonstrated on a large scale pressurised bed. To achieve 90% retention of sulphur, limestone will probably need to be added to the extent of ten times the weight of sulphur. This is more than twice the amount required for FGD. The reaction products, mainly calcium sulphate, will be left with the ash. There will also be a significant proportion of calcium oxide in the ash from thermal decomposition of the limestone. This reacts violently with water, producing heat and leaving highly alkaline calcium hydroxide which might be expected to set the ash mixture like a mortar.

The CEGB sells nearly half of the ash made in its power stations but it already has difficulty in finding suitable sites for the disposal of the remainder. The addition to that ash of wastes from the sulphur removal process in a fluidised bed would not make that problem any easier. The last thing we want to do is to trade a minor air pollution problem for a major land pollution problem.

A promising option in the Board's view is that of coal gasification, provided it can be developed to handle a wide range of British coals and be flexible enough to load follow. In co-operation with the National Coal Board, the CEGB has undertaken a conceptual study of the merits of various coal gasification systems which are air blown and produce a low calorific gas for electricity production. The gas produced would be burned in the gas turbine of a combined cycle and for maximum fuel economy the whole system would need to be highly integrated. The results of the study are currently being considered by the Department of Energy's Advisory Committee on Research and Development.

Sulphur in the coal is converted to hydrogen sulphide in the gasifier and can be removed if required in a gas clean-up stage to produce elemental sulphur or sulphuric acid which would have to be disposed of safely.

Similar considerations apply to the coal liquefaction process although in this case the Board would expect to buy in a suitable fuel. Fluidised bed combustion, gasification and liquefaction obviously require considerable development and are, therefore, long term options which are unlikely to make a significant contribution to electricity generation in the remainder of this century.

In addition to new ways of converting primary fuels to electricity much attention has lately been given to new energy sources. Of these the "renewable" sources, such as wind, sun, waves and tides have aroused considerable interest. In general the economics of all these systems does not compare favourably, at the present time, with conventional electricity generating methods. Wind, wave and tidal power have the considerable advantage of producing very little air pollution. They do however bring other environmental drawbacks. For example, producing significant power from the winds requires the use of large numbers of very large aerogenerators. These will be visually intrusive in some locations and could bring problems of noise and television interference. Wave power will bring safety problems associated with the need to build and maintain many kilometres of floating wave energy converters. Solar power is unlikely to be attractive in this country because of unfavourable climatic conditions and large land requirement. Tidal power may prove to be the most attractive of the renewable energy sources but may bring problems of noise and safety associated with the long construction times and in operation may considerably alter the esturial ecology. Despite these problems and the unlikelihood that they will contribute significantly to electricity supplies in the country until the next century, the CEGB is actively pursuing the study of these new forms of generation (22).

Energy conservation is claiming much attention these days as the government's "Save It" campaign showed. Economic

pressure are the main force behind the public determination to save energy but it cannot be denied that conservation brings environmental benefits. If we burn less fuel then it is likely that we will create less environmental problems during the combustion or conversion process. The current move to energy conservation can therefore be encouraged on environmental grounds including that of air pollution.

The CEGB has always been interested in the efficient use of fuel and has thereby contributed to the husbanding of fuel reserves. The combustion systems and boilers in power stations are carefully designed to maximise efficiency and much research effort has been expended in this field. In 1957 the overall thermal efficiency of the fossil fuelled power stations on the CEGB system was 25.51 per cent. In 1978/79 it was 31.85 per cent. This increase represents a saving of fuel equivalent to 29.5 million tonnes of coal in 1978/79.

The thermal efficiency cannot continue to grow indefinitely. It is limited theoretically by the Carnot cycle and practically by the Rankine cycle, governing the thermodynamics of the steam raising system. Using conventional systems about half of the heat value of the fuel must be rejected in the cooling system. The only way to increase the overall efficiency of the system is by using different combustion cycles or by finding uses for the waste heat. The CEGB has actively researched ways of using this heat but finding uses is not easy because in order to maximise the electricity generation then the large volume of heat emitted has to be at a very low temperature.

At one station the low grade heat of the cooling water has been used in specially constructed greenhouses and a commercial crop of tomatoes grown and sold on the open market (23). Although these greenhouses have been remarkably successful and helped in the efficient use of fuel they cannot be regarded as the sole answer to waste heat utilisation since it has been estimated that one 2000 MW power station could supply all the heat necessary for all the greenhouses in the UK. Another way of using the warmed water is in fish farming (24). While commercial fish farms using natural

waters are well established in the UK, there are not many farms using artificially warmed water. The CEGB has had experimental installations at several power stations and now has interests in two large fish farms at Drax and Trawsfynydd where trout and eel have been successfully grown.

Provided the basic requirement to obtain the maximum efficiency from the electrical generation at a power station is cast aside, it is possible to obtain higher grade heat and still achieve an overall increase in efficiency of fuel use. The CEGB has supplied process steam to factories close to some power stations and has had district heating schemes running for many years. This type of approach is referred to as "combined heat and power" (CHP). The CEGB assisted the Department of Energy's study in CHP under the Chairmanship of Dr. Walter Marshall (25). The "Report on Combined Heat and Power in the UK" concluded that CHP could be a viable economic option for heating buildings in areas of high density loads in the longer term. A potential fuel saving of some 20 Mtce was foreseen. An important consideration is use of plant of such a size that, but for the CHP operation, would have an efficiency equal to that of the largest units on the CEGB system. In practice this mean CHP units of 200 MW(e) or greater. As a result of this report the Department of the Environment has written to local authorities and others who might be interested in making a proposal for a "lead city" in which CHP proposals could be examined in some detail. The CEGB will assist in examining ways of supplying heat to CHP schemes and sees its future role as a bulk supplier of heat.

It is not just at the power station that fuel can be saved. By taking advantage of our integrated electricity supply network, the system can be managed to give, overall, the most efficient use of fuel. On the CEGB system the less efficient plant is used to follow the peaks and troughs of the daily load curve. Following the curve brings its own inefficiencies and by smoothing out the peaks generating plant can run more consistently and therefore more efficiently. Pumped storage schemes do just this, they use the efficient base load stations at night when demand is low to effectively "store" the electricity for times during the day when demand is high.

They thereby bring about an overall increase in the efficiency of the system. The CEGB operates a 360 MW pumped storage installation at Ffestiniog and is constructing a 1675 MW scheme at Dinorwic. The possibility of constructing another large scheme at Tintwistle in Derbyshire is currently being investigated.

The load curve can be managed in other ways. Recent developments include "teleswitching", which is still at the research stage. Here the power consumed by off peak devices, such as storage heaters, is remotely controlled by using a signal transmitted over the BBC radio wave bands. In this way the load can be turned on and off at the times which best suit the system. This may help to level out the peaks and troughs and result in a more efficient generating system.

At the point where electricity is used significant savings can be made. The Electricity Supply Industry has promoted better ways of insulating houses and is researching into energy efficient appliances. Too little attention has been paid in the past to the energy consumption of refrigerators, cookers and the like and there is ample scope here to benefit electricity consumers by redesign of the more conventional appliances and by adoption of small cooking appliances such as contact grills and microwave ovens. Another new development of interest is the heat pump. No manufacturer has yet produced a domestic version which will compete satisfactorily in the UK against alternative heating systems. Industry is however investigating this field. Properly designed heat pumps could provide a replacement for the older domestic boilers reaching the ends of their lives in the next ten years and may offer even more immediate opportunities in areas where oil is available but gas is not.

If all this work on conservation reads like an anti-sales drive for electricity, it is not. The Electricity Supply Industry intends to encourage the wider and wiser use of its product. In many areas, such as lighting and traction, it is the most efficient fuel. At its point of application electricity is virtually pollution free. The industry already has the duty to ensure economical and efficient production of its product. By taking a positive stance in

the market place it can play its part in ensuring that, in the national context, the most efficient use is made of fuel and the maximum benefit to our environment derived. It is the wasteful or inappropriate use of energy which must be curtailed so that as a nation we make the best use of our precious energy resources.

CONCLUSIONS

The Electricity Supply Industry has a responsibility to its customers and to the environment. In some cases this means balancing economic restraints against environmental objectives; in other cases the two go hand in hand. The industry has expended considerable effort in order to minimise the environmental effects of its actions. This is particularly true in the field of air pollution where the CEGB has achieved international recognition for its planning, research, design and operational work. Some problems still remain in this field and the industry will continue its work until an acceptable solution is reached. By and large however modern power stations can be managed so that their effect on the environment is small. At the present time there would appear to be no demonstrable need for any marked change of direction in the field or for any tightening of the pollution control standards already in force at power stations. Before such control increases are introduced that need will have to be clearly demonstrated if this country is to avoid the stringent economic penalties and the stifling of development which has already occurred elsewhere due to an excess of environmental legislation.

The economic case determines that future development must lie mainly with nuclear power stations. The CEGB will however wish to retain a considerable coal firing capability and the ability to expand it should the need arise. The CEGB will maintain its interest in the new coal combustion systems being developed but it is unlikely that they will make a significant contribution to electrical generation this century. The same is true of the use of renewable sources of energy for the purposes of generating a large proportion of the country's electrical energy. Whatever combustion or generation systems are chosen for the future, the CEGB will

still be charged with the duty of ensuring that they can be operated in a manner which is acceptable for the safety of the general public and the environment.

Economic pressures and the need to secure adequate future supplies of raw materials increase the need for conservation of our fossil fuel stocks. The Electricity Supply Industry has an increasing role to play in ensuring that the production and use of electricity is carried out in the most efficient manner. This can bring environmental as well as economic rewards. As a nation we need to ensure the wisest use of all our energy resources.

REFERENCES

1. Electricity Act (1957), H.M.S.O.

2. CLARKE, A.J., et al - Routine Sulphur Dioxide Surveys Around Large Modern Power Stations, Atmos. Environ., 10 265-268, 1976.

3. MARTIN, A., BARBER, F.R. - Sulphur Dioxide Concentrations Measured at Various Distances from a Modern Power Station Atmos. Environ., 1, 655-677, 1967.

4. MOORE, D.J. - SO_2 Concentration Measurements near Tilbury Power Station, Atmos. Environ., 1, 389-410, 1967.

5. BARRETT, G.W. - Methods of Calculating, Measuring and Monitoring Air Pollution Caused by Electric Power Stations in England and Wales, Clean Air, 9, No. 4, 119-134, 1979.

6. CAUNT, P. - Sulphur Dioxide around Eggborough Power Station. To be published.

7. LIKENS, G.E., et al - Hydrogen Ion Input to the Hubbard Brook Experimental Forest, New Hampshire, During the Last Decade. Water, Air, Soil Poll., 6, 435, 1976.

8. LIKENS, G.E., et al - Acid Rain. Scientific American, 241, 43, 1979.

9. GRANAT, L. - Sulphate in Precipitation as Observed by the European Air Chemistry Network, Atmos. Environ., 12, 413, 1978.

10. O.E.C.D., The O.E.C.D. Programme on Long Range Transport of Air Pollutants, 1977.

11. BARNES, R.A. - The Long Range Transport of Air Pollution. J. Air Poll. Control Assoc., 29, 1219, 1979.

12. BROWN, D.J.A., SADLER, K.M. - Correlation Between Ionic Concentrations in Lakes of Southernmost Norway - Data of Wright and Snekvik (1978) - and Implications with respect

to Sulphur Emissions, CERL Report RD/LN/1/80, 1980.

13. DOVLAND, H., et al - Deposition of Air Pollutants in Norway, 1976.

14. BERGE, F. - pH Changes and Sedimentation of Diatoms in Lake Langtjern, Norway, SNSF Report IR/11/75, 1975.

15. COGBILL, C.V. - The Effect of Acid Precipitation on Tree Growth in Eastern North America, Proc. First Int. Symp. on Acid Precip. and the Forest Ecosystem, Columbus, Ohio, 1976.

16. H.M.S.O., 111th Annual Report on Alkali etc. Works, Appendix VII, Notes on Best Practicable Means for Electricity Works, 1975.

17. GREEN, D.E. - The Investigation of Solid Particulate Aerosols in the Selby District Council Area. CEGB Report SSD/NE/R380, 1979.

18. CEGB, Submission to the Commission on Energy and the Environment, Coal Study, Topic 4, Combustion Residues, 1980.

19. CORBETT, J.O. - The Enhancement of Natural Radiation Dosage by Coal-Fired Power Generation in the United Kingdom. CEGB Report RD/B/N4760, 1980.

20. ROBSON, A. - Power Generation and the Environment. Proc. Symp. Energy and the Environment, Harwell, 1980.

21. HANSARD, Parliamentary Debates, 976, 90, 287-303, 18 December 1979.

22. LEIGHTON, L.H., WRIGHT, J.K., SYRETT, J.J. - The Potential for Unconventional Energy Sources for the United Kingdom. World Energy Conference, Istanbul, 1977.

23. Save Energy - Eat Tomatoes - Express News, Summer 1979.

24. ASTON, R.J., et al - Heated Water Farms at Inland Power Stations. Fish Farming International, June 1976.

25. The Combined Heat and Power Group - Combined Heat and Electric Power Generation in the United Kingdom. Energy Paper No. 35. H.M.S.O., 1979.

NATIONAL SOCIETY FOR CLEAN AIR

47th ANNUAL CONFERENCE
22 - 25 SEPTEMBER 1980
BOURNEMOUTH

NUCLEAR POWER AND THE ENVIRONMENT

by

Dr. L.E.J. Roberts, CBE,
Director, AERE Harwell

National Society for Clean Air
136 North Street
Brighton BN1 1RG
England

There are currently 11 nuclear power stations, with a total of 22 nuclear reactors on sites operated by the CEGB and the SSEB, generating 12-14% of our electricity, and an additional small contribution to the national grid from prototype reactors operated by the AEA and BNFL. The reactors operated by the Boards are gas-cooled reactors, Magnox or Advanced Gas-Cooled Reactor (AGR), both cooled by carbon dioxide gas but differing in size, form of nuclear fuel and thermal efficiency. The Government has recently announced a plan under which two more AGR stations will be built (at Heysham and Torness) and a first Pressurised Water Reactor, subject to the findings of a public enquiry. These stations will bring the total nuclear generating capacity in this country to 12 GW; the Government also envisages a further set of stations, to start in 1982/3, with a total capacity of 15 GW, though by the time all these are built and commissioned - near the end of the century - some of the older Magnox stations will have reached the end of their life.

The nuclear stations differ from the fossil-fuelled power stations only in the source of heat, a nuclear reactor being substituted for a furnace. Like the others, they are large installations, require cooling on a large scale, and need to be connected to the grid. The thermal efficiencies of the nuclear stations range from an average 25% for the Magnox stations to a designed 41% for AGRs, compared with an average 32-33% for all the fossil fired stations, so the cooling requirements are quite similar. Consideration of the safety of the general public influenced the growth of this new technology from the start. As a result, environmental considerations have always played a major part in the design and siting of nuclear power stations.

There are two major features of nuclear power which, from the environmental viewpoint, differentiate it from fossil fuel power. The first results from the very high energy concentration of the uranium fuel and the second from the fact that the fission process, the basic reaction on which the release of energy from uranium depends, is associated with ionising radiation and the production of radioactive materials.

The high energy concentration of uranium (1 tonne - 25,000 tonnes coal for thermal reactors, or 1,600,000 tonnes of coal for fast reactors) has the following consequences:-

(a) Mining The scale of uranium mining operations is comparatively small. Workable ores usually contain more than 0.1% of uranium and so the quantity of material to be mined and processed is about 1/20th of the amount of coal required for the equivalent energy production, even for the thermal reactor stations. The relative risks and environmental impact are similar to those of other mining operations but are reduced by the smaller scale.

(b) Transport Fuel and waste product transport requirements are much reduced. A typical nuclear power station needs ~ 16 lorry or truck loads of fuel a year (compared with ~ 5,000 train loads for a coal station) and produces 60 tons of spent fuel a year (compared with 1 million tons of ash from a coal station). The spent fuel, after 1-2 years' storage in cooling ponds to allow the radioactivity and associated emissions to decrease, is transported to Windscale in large, 50 ton flasks, which typically contain 1-2 tonnes of spent fuel. Thus the station does not need to be sited near the source of the fuel. Transport considerations do not seriously affect siting, and the situation of nuclear stations on coasts or estuaries explains the absence of cooling towers.

(c) Fuel and waste storage The fresh fuel store of a nuclear station is very small compared with the ~ 30 hectares and ~ 10 hectares needed for the coal store or tank farm of coal or oil fired stations. The facilities needed to handle the spent fuel are also small in scale compared with the problem of ash handling and disposal from a coal-fired station. A typical cooling pond measures about 20m x 10m x 5m, a smallish swimming pool.

(d) Effluents The scale of the effluent problem, too, is small for nuclear stations: the quantities of materials involved are such that almost all the waste products can be retained and later transported for treatment

elsewhere. Thus one does not need the tall stack required to disperse the very large amounts of airborne effluent produced in coal or oil fired stations.

The energy released from uranium fuel depends on the type of fuel used and on the type of reactor in which it is used. The fuel input into a Magnox, AGR and PWR reactor necessary to generate 1 GW(e)yr - 1,000 MW of electricity for 1 year - is summarised in Table 1. The Magnox reactors work on natural uranium metal fuel; the more advanced reactors, AGR and PWR need uranium oxide fuel which has been "enriched" in the fissile isotope U^{235} and the Table therefore shows the amount of natural uranium that must be fed into the enrichment plant at Capenhurst as well as the amount of oxide fuel that would be transported to a reactor.

The conventional environmental impacts of fuel and waste storage and transport are therefore slight and more attention has to be paid to the environmental effects of radioactive emissions, to which we now turn.

Radiation and Radiation Dose

The association of nuclear power with radiation is a major feature which determines the acceptability of this new technology by the public. Because of this, the nuclear industry is probably the most intensively studied and the most carefully regulated of all industries. Since the discovery of X-rays and of radioactivity in the last years of the last century, it has been recognised that mankind has always lived in a radiation field, from cosmic rays, from radioactive elements naturally present in the earth and even from the K^{40} in our own bodies. This natural background constitutes the largest source of exposure to man. In terms of the unit most commonly used, the rem*,

---

* the rem is the unit of dose equivalent; it is a measure of the quantity of radiation (or dose) received which allows for the different biological effectiveness of different types of radiation. A convenient smaller unit is the millirem (mrem); one rem = 1,000 mrem. (A new unit, the Sievert (Sv), is now being introduced. 1 Sv = 100 rem.)

the average annual dose from the natural background in the UK is 110 mrem* (just over one-tenth of a rem). Fig. 1 is taken from a recent assessment published by the National Radiological Protection Board[1] and shows how other sources of radiation compare with this source; note also that the variation in the dose from the natural background between different parts of the country is much greater than the absolute dose from such sources as fallout and radiation from the nuclear industry.

Radiation and radioactive materials can be accurately measured in the most minute amounts, and this circumstance, together with the widespread use of X-rays and of radiation sources in radiotherapy, has led to the intense study of their biological effects; we probably have better knowledge of these effects than we have of most chemical agents, including those emitted in the burning of fossil fuels. Actual data on irradiation doses throughout the world are collected and published every few years by the UN Scientific Committee on the Effects of Atomic Radiation (UNSCEAR).[2]

The general basis for the control of radiation exposure in the UK is the recommendations of the International Commission on Radiological Protection (ICRP) an independent scientific body that has been in being since 1928, which also form the basis for the relevant Euratom Directives.

The basic principles are:

(a) No practice (involving radiation exposure) shall be adopted unless its introduction produces a positive net benefit.

(b) All exposures shall be kept as low as reasonably achievable, economic and social factors being taken into account.

(c) The dose equivalent to individual shall not exceed the limits recommended for the appropriate circumstances by the Commission.

The limiting dose to any individual in a critical group

(a group most likely to receive some radiation dose) of the general public set by the ICRP in its latest publications is 0.5 rem per annum, about three times the <u>average</u> dose received from background and medical uses (of course individuals may receive much higher doses for medical purposes - 300-500 rem for therapy). Although the principal objective of radiation protection is to safeguard man, the ICRP believes that if man is adequately protected then other living things are also likely to be sufficiently protected.

The arguments that lead to these limits are essentially based on biological and clinical effects observed at much higher doses. Apart from acute effects that occur as a result of sudden exposure to doses of hundreds of thousands of rems, there are two effects that can occur following doses of the order of 100 rem - the delayed appearance of cancers and the possible effects of genetic damage. These are rare events even following large doses of radiation. Extensive studies of 82,000 survivors of the Hiroshima and Nagasaki bombs have shown that of the 4,000 cancer deaths that have occured, less than 200 can be ascribed to the radiation from the bombs: the remainder would have been expected in any unirradiated population of the same size. No genetic defects have been found in the offspring of the survivors; indeed, no genetic effect due to irradiation has been unequivocally found in man, but the possibility has been inferred from animal experiments.

The best estimate of the probability of a fatal cancer resulting from a dose of radiation, made by ICRP[3], is 1.25 in 10^4 per rem of whole body radiation, with a similar or smaller risk of a genetic defect in a subsequent generation. The delayed effects are, conservatively and for the purposes of radiological protection, assumed to occur at a rate directly proportional to the dose, even at the very low levels associated with the routine operations of the nuclear industry, although no such effects have ever been observed at such low levels. In other words, if 10,000 people receive 1 rem each, or if 1,000,000 people receive 10 millirem each, we might expect on these assumptions one cancer and one genetic defect at some time in

the future.

The ICRP estimates are generally accepted as the consensus in radiation biology although there is some evidence that they over-estimate the risk at very low dose rates. However, several studies have recently been published which suggest that the risk has been seriously under-estimated. The most quoted of these is by Mancuso et al, who consider that low doses of radiation may be 20 times as dangerous as suggested by ICRP. These suggestions have received wide attention in the press. A number of leading indepedent authorities on radiation and health effects have since published critiques that have raised serious doubts about the statistical techniques used and the conclusions of the Mancuso and other studies. Other independent studies, notably those of the Advisory Committee on Biological Effects of Ionizing Radiation have come to conclusions that are quantitatively and qualitatively very similar to those of ICRP. A recent study of the effect of diagnostic and low level therapeutic radiation on the development of leukemia showed no statistically significant increase after radiation doses of 0-300 rads administered in small doses.[9]

The harmful effects of radiation were broadly understood before the widespread introduction of nuclear electricity generation. The principles on which the control of radioactive emissions to the environment in the UK are based were set out in the Government White Paper Cmnd 884 in 1959 and have recently been reviewed by an Expert Group[4] and by the Radioactive Waste Management Committee. The principles are simply stated: radioactive materials can be dealt with either by dispersal or by containment. In the first case, reliance is placed on dilution being sufficiently large and rapid to avoid any appreciable risk to human populations. In the second case, containment must survive until the radioactivity has decayed sufficiently so that sensible risk is avoided, or ensure leak rates so low that concentrations everywhere remain negligible at all times.

Only materials of low activity levels are discharged to the

environment - gases to atmosphere, low-activity liquids to sea and low-activity solids either buried at shallow depths at the Drigg site or disposed of in the deep ocean after encapsulation in concrete, in accordance with international agreements. In the UK, no radioactivity can be released to the environment without permission from the Environmental Ministries and the MAFF. Operating limits for the various sites are set on the basis of an analysis of the most likely pathway back to man, which leads to a definition of the critical group of the population in each case. Some examples follow.

Emissions from Reactor Sites

Gases circulating in reactor circuits can become radioactive through irradiation. Radioactive argon, carbon dioxide and tritium can all be discharged from gas-cooled reactors. The major contribution to the dose arises from A^{41} and amounts to 130 man rem annually to the whole population; which can be compared with the natural radiation background dose to the whole UK population of about 6.6 million man rem per annum.

Active liquid effluent from reactor sites arises mainly from the appearance of some active species due to corrosion in the irradiated fuel cooling ponds. The ponds are provided with treatment plants but these in turn produce effluents which have to be discharged. Specific authorisations for discharge depend on the critical group identified in each case - for example, specific limits to Zn^{65} discharge are set at Bradwell because of the concentration of this nuclide in local oysters and to Cs^{137} at Trawsfynydd to cover the pathway back to man from freshwater fish in the lake. In all cases, discharges have been well below authorisation.(5)

Emissions from Windscale

The only public exposure of any significance from the nuclear industry results from the operation of the reprocessing plant at Windscale. Here the spent fuel, which has already been cooled for 1-2 years at the power station, is allowed to cool for a further period under water. It is

then processed chemically and divided into 3 streams - uranium, which can be recycled, plutonium, which is currently stored for use in future fast reactors, and the fission products, which constitute the highly radioactive waste.

This high-level waste, as it is called, is small in volume. Every GW-year of electricity generated in nuclear stations gives rise to $4m^3$ of it, and these small volumes of highly active liquid are currently stored in double-walled stainless steel tanks. The plan is to convert this liquid into blocks of a stable, glassy solid which can be further stored with simple cooling arrangements in strongly constructed stores that provide adequate shielding. Such a configuration would be very safe indeed: it is difficult to conceive how any of the activity could ever re-enter the environment. Research is now in progress into the options of eventual disposal of the solidified waste blocks either into deep geological strata or on or under the bed of the deep ocean, options which would interpose more barriers between the waste and man.

The operations of the reprocessing plants give rise to other waste streams and to the release of active gases to the atmosphere and low-level liquid wastes to the Irish Sea, down a pipeline which extends into the sea 2.1 km from the low water mark. Much of the evidence at the Windscale enquiry concerned these releases.[8] The largest amount of gaseous activity releases is Kr^{85}; it may be necessary to remove and contain the active Krypton in the future if the scale of operations increases and means of doing so are being developed. The liquid discharges constitute the only significant dose to members of the public; it was calculated that a member of the local fishing community consuming the maximum amount of fish and shellfish caught in the immediate Windscale offshore area would have received in 1977 about 30% of the ICRP dose limit. If exposure at this level was attained it will have been by only very few people; a typical member of the fish eating public eating fish landed at Whiteheaven and Fleetwood would have received 1.2% of the ICRP does limit due to this cause.

The Department of the Environment publish an annual survey of radioactive discharges in Great Britain.[5] It is based on reports published annually by UKAEA, CEGB, BNFL and the Fisheries Radiobiological Laboratory of MAFF and data from SSEB and The Radiochemical Centre Ltd. The latest report, published in 1979, shows that all emissions from all nuclear installations are within the authorised levels and that no member of the public has received a dose exceeding the ICRP limit. For the great majority of installations the most highly exposed member of the public received less than 1% of the ICRP limit. Emissions from the installations listed in Table 2 resulted, in 1977, in exposures to a few individuals of between 1 & 30% of the ICRP limits.

The National Radiological Protection Board publishes calculations of the annual collective dose equivalent to the UK population from discharge of radioactive effluents of all types. Their latest report[1] shows that the liquid discharges from Windscale are now the largest contributing factor and the increase in these discharges since 1972 the sole reason for the increase in the total since that date. The discharges of liquid effluents from Windscale are likely to be reduced considerably within the next few years following the installation of a pond treatment plant but BNFL have already taken some intermediate measures which have limited the annual discharge since 1976.

Any measures to reduce this discharge can only be seen as designed to reduce further a risk which is already small. The most exposed individual identified in these surveys accumulated in 1977 a dose that increased his risk of developing cancer by 1 in 30,000; statistically, anyone has a 1 in 5 chance of dying of cancer. The risk to the population as a whole arises from an annual dose equivalent of 12,500 man rem; on the quite conservative assumption that the ICRP estimates apply to the very lowest doses, this would imply between 1 and 2 additional cancer deaths somewhere in the UK, to compare with the current total of 140,000 per year. Many of these cancer deaths are thought to be due to environmental agents since know carcinogenic substances are produced in various industrial processes and some during the incomplete combustion of fossil fuels. On

the basis of the same conservative ICRP assumptions, about 600 of these cancer deaths per year might be ascribed to the natural background radiation, though there is, of course, no direct evidence for this. Fig. 2 enables a comparison to be made between the contributions to dose for the nuclear industry and other man-made sources during the last 20 years, with some extrapolation to the future, which is discussed below.

SAFETY

The data and the surveys discussed so far relate to the normal operation of plants and of reactors. Another subject which is of high public interest is the safety of nuclear installations, particularly of reactors - i.e. of the possibility of the occurrence of serious accidents which would lead to the unauthorised release of activity. Uncertainty about the characteristics of a new technology led to a restrictive siting policy which results in all of the Magnox stations (with one exception) and the first two AGR's being located in coastal areas having population densities about 1/10 of the average for England and Wales and approximately one hundredth of the density in large towns. This siting policy was revised in 1968 to permit the use of sites closer to centres of urban population for reactors with pressurised concrete pressure vessels.

The responsible body for licensing commercial nuclear reactors and plants is the Nuclear Installations Inspectorate, which forms part of the Health and Safety Executive. The generating Boards, and the AEA carry the executive responsibility for the safe operation of their own plants and maintain within their own organisations independent departments to advise their Boards on safety matters. The HSE also draws on the advice of the Advisory Committee on the Safety of Nuclear Installations, an independent body chaired by Dr. Sugden. The total resources devoted to safety matters are a large fraction of the total development work undertaken both by the AEA and by the industry.

Safety features are built in to the design of a reactor on

the basis of a probabilistic calculation of the consequences of faults and errors. A complete range of all foreseeable fault conditions is analysed and a fault and accident diagram produced. The failure probabilities of individual components can often be assessed on the basis of statistical information accumulated in many industries. The aim of the overall analysis is to identify those event sequences and system failures which could give rise to radioactive emissions so that the safety features incorporated into the design can reduce the risk of their occurrence to an acceptably low level. The criteria adopted for the design of nuclear installations are very strict and the results of safety analyses that have been published reflect this very conservative approach. For example, comprehensive safety analyses of Pressurised Water Reactors have been made in the USA and, more recently, in Germany. The results show that both the risk to an individual and the probability of occurrence of large accidents killing many individuals is much lower than risks from natural causes or from other industrial installations. The standards set for the nuclear industry are comfortably within those recommended by the Advisory Committee for Major Hazards in its first report published in 1976.

The actual safety record in the industry has been very good. Worldwide, we have experience of about 1,500 commercial reactor operating years over a period of about 25 years, with no known casualties resulting from it. The most serious accident in the UK occurred at Windscale in 1957, involving the overheating of an air-cooled reactor producing military material. The main consequence was the emission of about 20,000 curies of I^{131}; there is no evidence of harm to people but the consumption of milk was prohibited from an area of about 200 square miles for varying periods of up to 6 weeks. The most serious accident yet to a commercial operating reactor was the very well publicised accident to a PWR at Three Mile Island, Pennsylvania in March 1979. Very extensive damage occurred to the reactor and some evacuation of nearby population was ordered - unnecessarily as it turned out - but the actual release of activity was very small, less than one per cent of the annual background level, averaged over a 50-mile

radius, and less than 10% of the annual background level to people living within 5 miles of the plant. To quote the Kemeny Commission's report to the President - "... the radiation doses were so low that we conclude that the overall health effects will be minimal. There will either be no case of cancer (resulting from the accident) or the number of cases will be so small that it will never be possible to detect them. The same conclusion applies to other possible health effects."

The reactions to the Windscale accident in the UK led to a considerable tightening and reinforcement of the mechanisms for control of the nuclear industry in the UK, and there is no doubt that the same will happen in the USA.

There has been recent interest in the safety of transport of radioactive materials, particularly in the transport of spent fuel to Windscale. Regulations for the safe transport of radioactive materials have been published by the International Atomic Energy Agency, and these form the basis for the approval of container design in the UK, which is a responsibility of the Department of Transport. Containers are designed so that any spread of radioactive material under accident conditions is minimised, and are subject to drop tests, penetration tests, exposure to fires and water immersion tests. A typical container is shown in Fig. 3. A film of some tests of full scale spent-fuel containers in collisions which were carried out by the Sandia Corporation in the USA, will be shown at the end of this talk. A good example of the care with which safety assessments of transport operations are made was the assessment of the transport of plutonium nitrate solution published last year by the Health and Safety Executive.

THE FUTURE

What of the future? Will the environmental detriments I have described simply increase in proportion to an expanding nuclear programme? A study of trends in radiation exposure of the population was included in NRPB-R77[1]. On the assumption that the nuclear installed capacity will rise from 9 GW in 1980 to 40 GW by the year 2000 - which now

seems a high assumption - Taylor and Webb estimate that the collective dose equivalent received by the general UK population in the year 2000 from discharges from nuclear installations may rise from the present 12,500 to 30,000 man rem; the estimate includes doses received from foreign installations. At that level it will be about half the residual radiation in 2000 from fallout from weapon tests, much smaller than doses from medical irradiation and about 0.5% of the natural background level. These estimates have been plotted, as dotted lines, in Fig. 2.

One innovation in reactor technology should be with us by the year 2000 and should make an increasing impact thereafter - the fast reactor; the AEA is already operating a 250 MW(e) prototype at Dounreay. Fast Reactors use a mixed plutonium-uranium oxide as fuel and the only difference in the fuelling arrangements between fast and thermal reactors is that the fresh fuel, as well as the spent fuel, has to be transported in massive steel flasks - in order to satisfy security regulations, not because of the intrinsic activity of the fuel. A few more heavy consignments will then be required per year.

The design of fast reactors which is the leading design in every country interested in fast reactor technology depends on sodium as the primary cooling medium. The technology of handling sodium is now becoming well understood and we don't anticipate difficulty on that score. The safety case for a fast reactor involves new considerations because of the different neutron economy in the reactor core. But experiments aimed at determining the safety characteristics are going well; a fast reactor will have some inherent advantages over thermal reactors, such as the enormous thermal inertia of the large pool of sodium which surrounds the assembly of fuel elements, which means that there is a lot of time in which to deal with any accident involving loss of cooling to the reactor. It looks as if fast reactors will be acceptable on any reactor site, though the Nuclear Installations Inspectorate may well insist on a site of low population density for the first commercial fast reactor.

Waste handling and emission will be no more difficult than for thermal reactors; indeed on a global scale the environmental impact will be smaller. The International Fuel Cycle Evaluation Study compared the collective dose commitments from the waste arisings of several reactor types per GW-y of electricity produced on standardised assumptions in each case. Some of their findings are summarised in Table 3. The fast reactor, working on a U-Pu fuel cycle, gives rise to the lowest dose commitment of any studies, for a very simple reason - it uses the uranium so efficiently that very little uranium has to be mined to maintain it. That is not an advantage that would actually accrue to us in this country, but there is no reason to suppose that the environmental impact of fast reactors in this country will differ significantly from those which we have today.

The overall conclusion is that the environmental impact of the nuclear component of our power generating industry is low and likely to remain so. Safety standards, which are already good, are in fact improving as time goes on and we have now reached the point where it is necessary to achieve a balance between the investment needed to improve standards further and the very marginal - even problematical - gains in practical terms which is all that can be achieved.

REFERENCES

1. Radiation Exposure of the UK Population. F.E. Taylor & G.A.M. Webb. NRPB - R77 (November 1978).

2. United Nations Scientific Committee on the Effects of Atomic Radiation Sources and Effects of Ionizing Radiation (1977).

3. ICRP Publication No. 26 (Pergamon Press, Oxford 1977).

4. A Review of Cmnd 884 "The Control of Radioactive Wastes". A report by an Expert Group made to the Radioactive Waste Management Committee Department of the Environment, September 1979).

5. Annual Survey of Radioactive Discharges in Great Britain 1978. (Department of the Environment, Scottish Office and Welsh Office, 1979).

6. International Nuclear Fuel Cycle Evaluation. INFCE/PC/2/7 (February 1980).

7. Health & Safety Executive Report NII/R/39/78, (December 1978).

8. Windscale Inquiry Report. Mr. Justice Parker, (January 1978) HMSO

9. Linos et al, New England Journal of Medicine, Volume 302, p. 1100 (May 1980).

Table 1 Materials flow for 1 GW(e)yr

	Fuel in to Enrichment plant	Fuel in to Power Stations	Power Station Efficiency	Spent Fuel out of Reactor
Magnox *	—	396 tonnes natural U	~25%	396 tonnes in 190 containers (total 9,600 tonnes)
AGR ⊬	235 tonnes natural U	50 tonnes enriched UO_2	~40%	50 tonnes in 57 containers (total 2,800 tonnes)
PWR ⊬	240 tonnes natural U	36 tonnes enriched UO_2	~32%	36 tonnes
Coal	—	3,600,000 tonnes	~32%	**Emissions** 730,000 tonnes of ash

* CEGB statistics
⊬ Planning figures

Table 2 UK nuclear installations contributing doses in 1977 to members of the public greater than 1% of the ICRP limit

Installation	Radionuclide Critical Group	% ICRP
Windscale and Calder Works	Cs 134 & 137 single critical fish eater	~ 30
	critical group of local fishermen	~ 13
	typical member of public eating fish landed at Whitehaven & Fleetwood	~ 1
	Ru-106, Am-241 single salmon garth fisherman	~ 4
	Ar-41 individuals living very close to Calder reactors	~ 2.5
	Sr-90 infants drinking only milk from nearest farms	~ 3*
Harwell, Winfrith, Dounreay	I-131 infant drinking only milk from nearest farms	3*
CEGB Reactors Trawsfynydd	Cs 134 & 137 local fisheaters	3
	Ar-41 individuals living very close to reactor	3

* (corresponds to minimum detectable level; probable dose much lower).

Table 3 Summary of collective dose commitments (kman rem) from waste arisings of reference fuel cycles per GW(e)y of electricity

Wastes	PWR once-through	FBR U—Pu cycle
Wastes from ore processing	37	0.2
Refining, conversion and enrichment wastes	27 — 9.0*	—
Unreprocessed spent fuel	8.9 — 27*	—
Reprocessing wastes	—	1.8 — 5.2*
Sum total (approximate)	70	6

* Upper and lower figures calculated on different assumptions of migration of radioactivity in the environment.

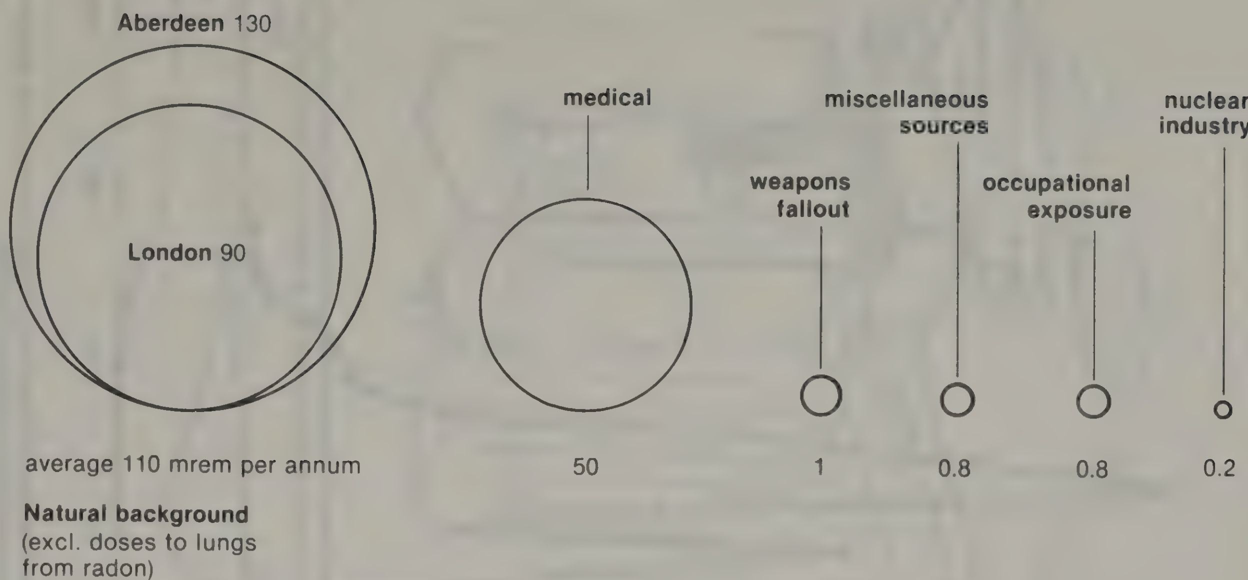


Figure 1 Sources of radiation in the UK

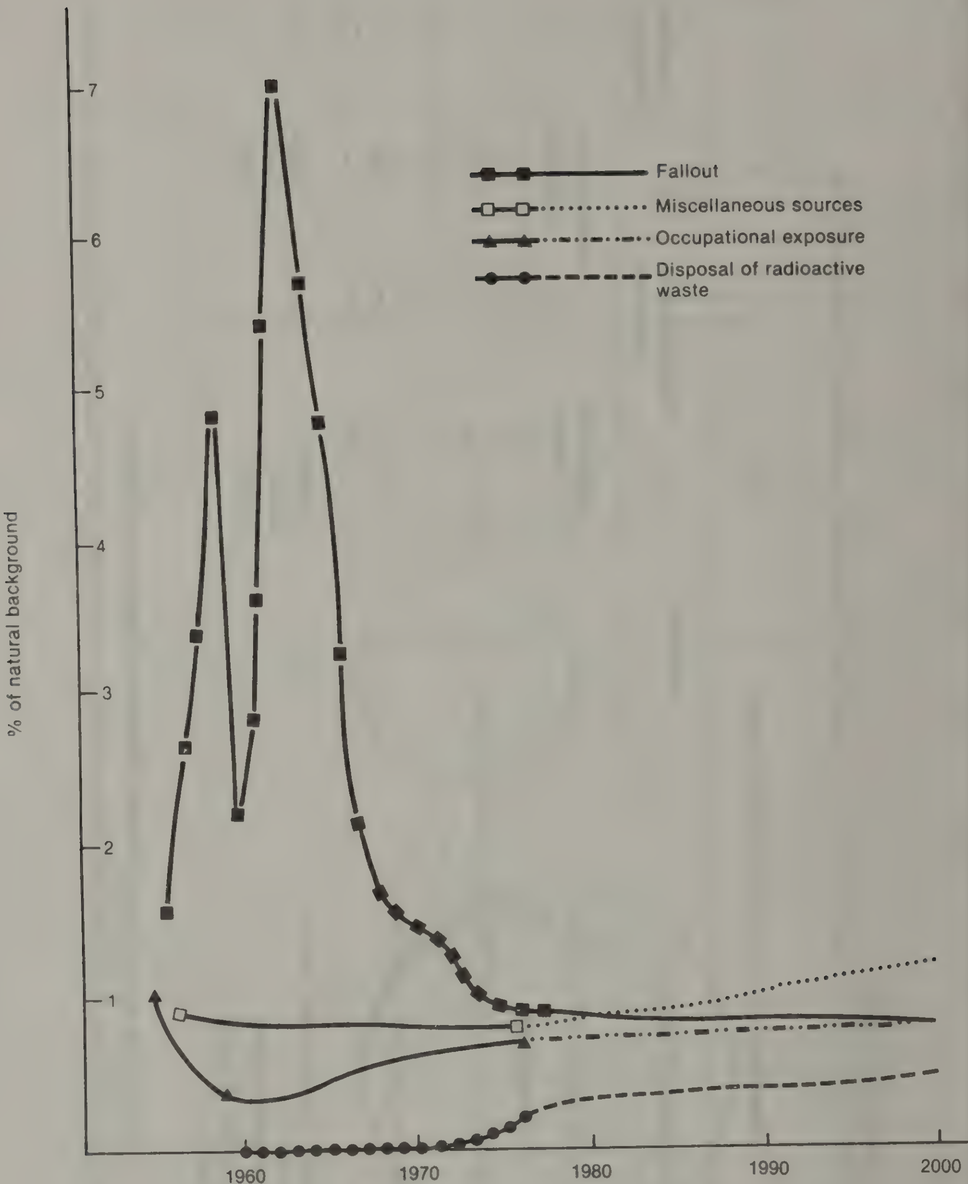


Figure 2 Annual per caput effective dose equivalent from man-made sources of radiation exposure (excluding medical irradiation) 1950-2000.

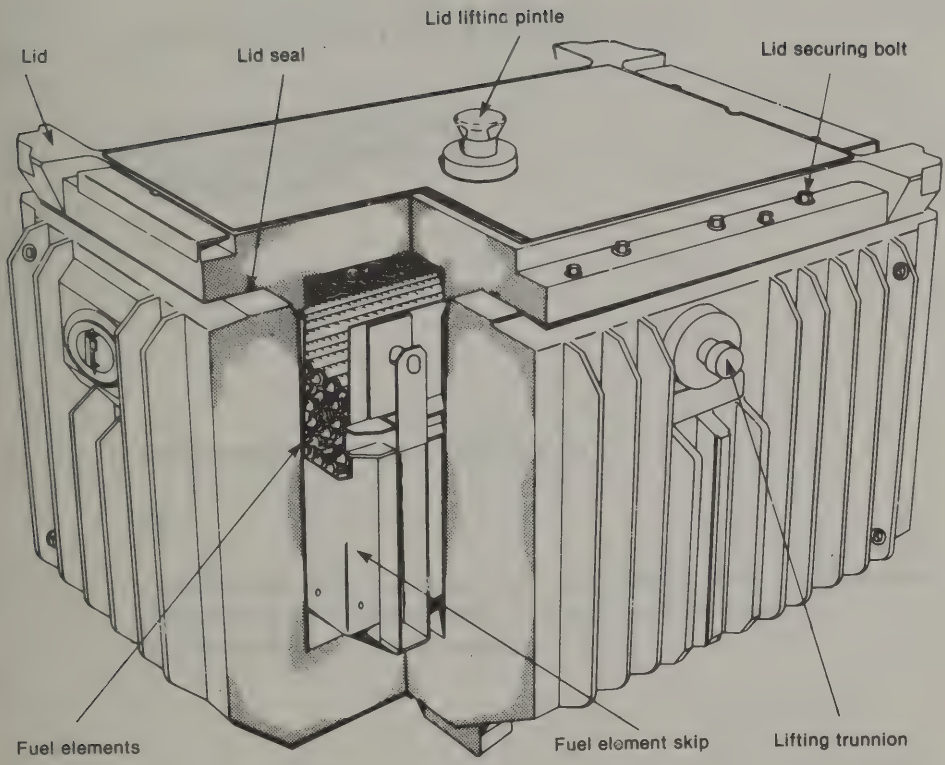


Figure 3 Transport flask for irradiated fuel elements from Magnox nuclear power stations. The flask's overall dimensions are: length 256 cm (8 ft 4¾ in), width 218 cm (7 ft 1¾ in), height 221 cm (7 ft 3 in).

NATIONAL SOCIETY FOR CLEAN AIR

47th ANNUAL CONFERENCE
22 - 25 SEPTEMBER 1980
BOURNEMOUTH

ENVIRONMENTAL NOISE CRITERIA

by

Professor J.B. Large, I.H. Flindell and J.G. Walker
Institute of Sound and Vibration Research,
University of Southampton

National Society for Clean Air
136 North Street
Brighton BN1 1RG
England

INTRODUCTION

1.1 This paper sets out to describe a selection of environmental noise criteria for use by building designers, and to examine the rationale behind the development of those criteria. It is not concerned with the assessment of the range of noise levels which can cause damage to hearing, but with those levels of environmental noise which can cause activity disturbance or interference with relaxation, sleep, or communication. Furthermore, and perhaps more importantly, it is concerned with perceived environmental quality.

1.2 In the United Kingdom considerable effort has been expended on formulating methods for quantifying levels of environmental noise. This has resulted in the adoption of a variety of noise scales and indices for use in evaluating environments over a wide range of different conditions. For example, the Noise and Number Index (NNI) is used for aircraft noise, the L_{10} (18 hour) for road traffic noise, the Corrected Noise Level (CNL) for noise from industrial premises and other fixed installations, and Leq dB(A) for railway noise, construction site noise and noise abatement zones. The Noise Criteria and Noise Rating curves are often used for the assessment and design of indoor environments.

1.3 However, this proliferation of different noise indices and scales for use in different situations and with different noise sources can lead to confusion and difficulties, especially in the valuation of complex environments resulting from a number of noise sources. The concept of the unique dose-response relationship seems attractive but it has not to date been employed with particular success. There are also problems caused by the necessity to balance the benefits of ideal noise criterion levels against the costs of noise reduction measures. Thus those individuals or communities which may be especially sensitive to noise can only expect degrees of protection which would produce an acceptable environment for the majority.

RATIONALE

2.1 Environmental noise criteria are specified levels of

noise, expressed in terms of scales or indices, which are selected to define degrees of acceptability, or to define appropriate use or design. Any criterion must use a scale or index which can be measured or predicted sensibly, and they are invariably defined in terms of a specified function of sound pressure level, expressed in decibels (dB) and variation with time. A noise scale may be used to describe a non-varying noise, or the peak level of a noise event and is obtained by applying some form of frequency weighting to the measuring instrument. Examples are the dB(A), dB(B), and dB(C) scales. A noise index includes an allowance for variations of noise level with time, and may also be situation dependant; for example, the level of background noise could be included, or the time of day or night could be allowed for with a weighting factor.

2.2 In order to satisfy the demands of objectivity, noise indices and scales must be reliable and repeatable. Various standards have been laid down as to the required precision of measuring instruments (see for example BS 4197: 1967 "A Precision Sound Level Meter") (BSI, 1967). The criterion should state precisely (or by direct reference to published standards) the procedure to be adopted for measurements or predictions, and the procedures must be applied by competent staff.

2.3 Any noise index or scale used in a practicable criterion must be measurable economically with existing technology. This constraint is gradually being relaxed with the introduction of microprocessors, but the long-term averaging of noise levels to yield indices such as the 24 hour Leq can still require large amounts of manpower, as no system yet devised can reliably identify contributions to the overall environment from any one particular source, without the aid of the noise expert's ear.

2.4 The degree of acceptability, or definition of appropriate use or design, must be obtained by measurement, or inferred from experience. Measurements of degrees of acceptability can be obtained from social surveys, case histories, complaint studies, behavioural observations and laboratory studies. Each research method must be applied in

conjunction with objective measurements or predictions of noise levels, in order to enable criteria to be defined. It is often necessary to amass large amounts of data in such a programme, as the best method of measurement of both the noise levels and their effects cannot be known until the end of the study. It is recommended that some form of standardised research procedure should be adopted in future (Large, Rice, Walker and Fields, 1978) in order to be able to make meaningful comparisons between studies. These recommendations include the use of Leq as an objective noise descriptor for all studies, the use of a core of standardised questionnaire items in social surveys and laboratory studies of annoyance, the development of methods for combining the contributions from laboratory and field studies, and the inclusion of a wide range of acoustical and situational variables in each study.

2.5 There are a number of effects of noise on man which could be measured in order to define criteria in terms of degrees of acceptability. As well as being able to cause a reduction in perceived environmental quality, noise can have a physiological effect on the auditory and non-auditory systems, and it can interfere directly with relaxation, sleep, communication, or task performance. In a review of these effects Bastenier, Klosterkoetter, and Large (1975) were able to draw the following conclusions.

2.6 Autonomic responses Although a great deal of work has been reported concerning cardiovascular, respiratory, pupil dilation, skin resistance and hormonal responses to noise stimulii in laboratory situations, it is extremely difficult to use the data to define degrees of acceptability as it is not known whether any particular autonomic responses are potentially harmful, and indeed, whether the same responses occur in real-life. There is a limited amount of evidence for increased rates of foetal abnormality and cardiovascular disease, for example, near airports, but it is very difficult to conclude that these effects are caused solely by noise, or what part noise plays. This type of response is of limited value for the selection of environmental noise criteria.

2.7 Sleep disturbance Noise can delay or even prevent

sleep by keeping arousal levels too high, and it can also alter cyclic sleep patterns by causing changes in sleep stage. Generally speaking, sleep disturbance does not occur when the indoor night-time equivalent noise level is below 35 dB(A) and the average maximum level of peak noise events does not exceed the equivalent continuous noise level by more than 10 dB. However, awakening thresholds depend to a great extent on a number of non-acoustic variables, and furthermore, there is no conclusive evidence on the extent to which prolonged disturbance to sleep patterns can affect health.

2.8 Noise and Relaxation The effects of noise on rest and relaxation are very difficult to quantify. The individual state of mind plays an important role in determining the degree of disturbance but for rest and relaxation associated with sick and convalescent persons daytime equivalent sound levels of 45 dB(A) would appear to provide an adequate indoor environment. At night the levels ought to be 5 to 10 dB lower.

2.9 Task interference These effects have been investigated mainly in laboratory experiements. There appears to be no significant interference with work or other activities which do not depend on the assimilation of acoustic information if the steady noise level is below 90 dB(A). Tasks that require a high degree of concentration are more readily disturbed. Impulsive noise can cause significant task interference if it induces startle and causes arousal of the central and autonomic nervous system. However, the levels of noise that have been demonstrated to cause task interference are much higher than the levels that would be considered desirable from other points of view. Thus task interference cannot form a basis on which to select environmental noise criteria.

2.10 Speech interference High levels of speech intelligibility are essential for reliable communication. Speech intelligibility is a function of normal or raised voice level, distance between communicants and background noise and is quoted as a percentage of correctly understood syllables. (Speech interference, on the other hand, is the percentage of incorrectly understood.) Figures 1 and 2 (Miller, 1971) illustrate these functional relationships. Good speech

intelligibility can be achieved outdoors at one metre distance with a background noise level of 65 dB(A) equivalent continuous sound level (Leq) or less. This is assuming normal conversational levels. Reduced conversation levels, such as may be encountered during a medical consultation, or tutorials, require background noise levels of 5 to 10 dB lower, in order to maintain the same levels of speech intelligibility. In situations where the noise includes large variations in level, for example near an airport, motorway, or railway, then a lower level of background noise expressed in terms of Leq is also necessary for clear speech recognition. All these points also apply to conditions for viewing television, listening to radio, or participating in a telephone conversation.

The importance of good conditions for speech intelligibility is borne out by the fact that speech interference is often mentioned as a particular disturbance in social survey investigations.

2.11 It can be seen that physiological responses to, and activity interference caused by noise do not form relationships that can be easily adapted to select generalised environmental noise criteria. Task interference results only from what would otherwise be considered excessive levels, and thresholds for minimum or zero sleep disturbance are so low that it is not always possible to achieve the requisite levels within typical urban environments. If people wish to have the benefits of industrialisation, then, with current technology, there is an economic limit to the amount of noise reduction possible, which defines the levels of noise which those people may have to put up with, irrespective of the acceptability of those noise levels in any absolute sense. As regards speech interference, it is difficult to select levels on the basis of acceptability, since in different situations people are accustomed to employing different speech levels in order to achieve whatever level of intelligibility they desire. Thus the above effects could only serve to define noise criteria under specific and narrow circumstances, and are not suitable for the general case.

2.12 Perceived environmental quality is an important aspect of the selection of noise criteria. It depends upon human value judgements and is something which can be measured subjectively but has no absolute determinants. It is also a factor which can be evaluated on a continuous scale, varying in relative terms from "unacceptable" to "acceptable" or even "desirable". It offers an opportunity for trading off the subjective effects of environmental noise against the costs of noise reduction measures and thus provides a sound basis for the administrative procedure of setting criteria. It provides each individual with the opportunity to make his own assessment or subjective weighting of the relative importance of each type of noise nuisance or disturbance in forming a judgement of perceived environmental quality.

2.13 The most convenient way of measuring perceived environmental quality is to examine annoyance responses by means of questionnaires, either in field surveys or laboratory studies, or both. The view that is sometimes held, that annoyance responses are little more than fickle responses of cranks or unstable persons, is easily dealt with by reference to the large body of data showing consistent increases of degree of reported annoyance with noise level. Degrees of annoyance can be measured by using a scale with labelled end points at "no annoyance" and "extreme annoyance", and depends upon the unannoyed or marginally annoyed person considering for himself the sorts of situation where he might react with extreme annoyance. Survey data have shown only mild relationships, if any, between expressed annoyance and established measures of personality such as neuroticism or stability, and relationships between noise sources and respondent's source of employment and income do not, in general, influence noise annoyance. Furthermore, although complaints about a noise source often increase dramatically during media exposure or publicity campaigns, noise annoyance, as measured on noise annoyance scales, persists for sources which are not the subject of public attention (e.g. railway noise; Fields and Walker, 1980). Possible bias introduced by drawing attention to a noise source can be eliminated by employing 'concealed' questionnaires which are ostensibly about other environmental matters and only introduce noise unobtrusively. There is evidence to show that even this

form of possible bias might not be important, as surveys which included up to thirty minutes discussion on noise have not shown any shift in expressed annoyance between concealed items at the beginning and repeated, open items at the end.

2.14 A consistent picture has emerged from a number of studies of the nature of expressed noise annoyance. At high noise levels, it is correlated with various forms of activity disturbance and communication interference. Annoyance reactions are not only affected by the level of a particular noise source, but also by the degree to which the individual holds certain attitudes, and the individual's degree of noise sensitivity. Greater expressed annoyance is associated with the belief that the noise could be prevented (misfeasance) and that health may be affected by noise. In a recent field study of noise annoyance associated with a regular helicopter shuttle service it was noted that certain individuals expressing high annoyance held the incorrect belief that passengers could look down on them. Thus, the sound of the helicopter became annoying, partly because it reminded those individuals of their belief in the invasion of their privacy. Fear of airplane crashes is strongly associated with expressed annoyance to the noise of airplane flyovers.

2.15 Notwithstanding the various attitudinal and psycho-sociological variables which can affect perceived environmental quality as expressed in terms of noise annoyance, the correlation with acoustical factors alone is generally sufficiently high (when considering the mean scores of homogeneous groups of persons) to enable perceived environmental quality to be used in selecting environmental noise criteria. Furthermore, the quantification of the subjective effects of the various non-acoustical variables constitutes a fruitful research topic, with obvious applications in terms of noise criteria. For example, a recent comparison of annoyance reactions to railway noise versus aircraft and road traffic noise has shown that railway noise is less annoying at the same noise level. This difference is presumably partly due to differences in attitude to railway noise and other transportation noises (a non-acoustical

factor) as well as acoustical factors and could be included within general forms of noise criteria, or allowed for in source specific noise criteria.

THE IDEAL

3.1 We can now take this opportunity to summarise the factors involved in the selection of an ideal noise criteria. First of all, the criteria must be consistent with the mean annoyance response of the exposed population. Secondly, the noise scale or index must be capable of being measured reliably, accurately, and repeatably. Finally, the criteria must be used and be seen to be reasonable and effective, and then it may become more and more widely used.

3.2 Unfortunately, because of the known large individual differences in expressed annoyance scores at each noise exposure level, it is not possible to devise any noise criterion that will work equally well for all individuals (see Fig. 3). Thus the mean annoyance response must suffice, although where the costs of noise control permit it, it is possible to choose an annoyance response percentile above the mean in order to protect a proportion of those persons having above average sensitivity. Conversely, when costs would be excessive it may be necessary to choose a percentile below the mean.

3.3 A further problem arises with non-acoustical variables. It is a known fact that the relationship between expressed annoyance and noise level are source specific (as mentioned above). No simple noise scale differentiates between sources in any way that could be used for the selection of criteria. Thus one of the goals of the Noise Advisory Council (NAC), to develop a single unified noise index for the selecting of criteria for all noise sources, remains some way from solution. It is perfectly possible, and even reasonable, to measure all noise sources in terms of a common noise index, for example, Leq, but it is a different matter entirely to select levels of Leq that can be used to define criteria independently of source. Leq is a sensible unified noise index for use in complex noise environments for comparing and contrasting the energy contributions of each

source. It can also be used to show how the energy contribution of a single source can change in importance with future development. However, it cannot be used in isolation to predict reliably the contributions to overall expressed annoyance from each source as it is possible that any one source could be dominating the mean annoyance response, even though it has only a similar Leq level to the other sources.

3.4 There is some evidence from laboratory studies on multiple noise sources, that even if the effect of different dose-response relationships for different noise sources is weighted out, a combination of two sources at equal subjective levels gives rise to much more annoyance than would be predicted on the basis of energy summation alone (Powell, 1979). Thus the effect of the introduction of a new source at the same Leq level as the existing noise environment could be compared with the effect of increasing the existing noise level alone by up to 10 dB, instead of the 3 dB predicted by a simple Leq model.

3.5 The problem of weighting for different sources is no more simple than the problem of weighting for different times of day. Although it is true that individuals may be more sensitive to noise during particular periods of a 24 hour day (for example; when trying to go to sleep), research to date has been inconclusive as to by how much noise levels should be weighted during the sensitive periods. In part this may be due to the use of data which has only been obtained indirectly, for example, in the Second Heathrow Aircraft Noise Survey (OPCS, 1971) it was noted that scores on a night-time annoyance question (asked during the day-time) correlated less well with night-time exposure than did general annoyance with day-time exposure. Furthermore general annoyance correlated more highly with night-time exposure than did specific night-time annoyance. This may have been because day-time exposure is more important in determining general annoyance reactions and that the correlation between night and day exposure tends to be stronger than any tendency for expressed night-time annoyance to correlate with night-time exposure. The technique presently adopted by Venet in France (Vernet, 1979) may

have greater construct validity. Disturbance of sleep by transportation noise sources has been studied through in situ physiological recordings. However, this approach suffers from having no direct transformation to perceived environmental quality.

3.6 Thus it can be seen that there is no conclusive evidence for the adoption of any particular night-time noise weighting as, for example, 10 dB in the American L_{dn} index. Recent laboratory work, again using indirect questionning techniques, suggests that a 5 dB penalty could be more appropriate for night-time noise. There is some evidence that, given the way in which noise levels typically drop dramatically at night-time, the evening period may be the most important as far as annoyance responses are concerned. A recent combined field and laboratory study at I.S.V.R. showed a high correlation between field and laboratory scores when field questionnaires and the laboratory phase were closely related to the 1900 to 2100 hours evening period.

3.7 In fact, there is much to be said in favour of combined laboratory and field studies of the annoyance reaction to various noise levels. The laboratory technique offers an opportunity to present experimental subjects with a wide range of closely controlled conditions, and if it is closely tied to a social survey, it can be validated against responses to real-life long term exposures.

3.8 In summary it can be stated that there is at present no fully validated unified index which could be used to replace the variety of separate indices for specific sources which will be described in the next section.

CURRENT NOISE INDICES

4.1 This section will give a brief description of the noise indices currently employed for the setting of criteria in the United Kingdom, in the light of the points covered above.

4.2 For a significant number of persons living near to major airports, the noise caused by overflying jet aircraft can constitute the major contributor to the noise energy received

at their dwellings. A social survey and noise measurement programme was carried out in Summer 1961, involving 1909 interviews and measurements at 85 points within ten miles of London Heathrow Airport. The Noise and Number Index (NNI) was developed from these data, and was based on the observation that multiplying the number of aircraft by four, without change of noise level, was equivalent to raising the noise level of each aircraft by 9 PNdB without change in number, in terms of expressed annoyance. (PNdB, perceived noise level in decibels, is a complex form of frequency weighting of a noise and was developed from laboratory studies of aircraft flyover events. Generally speaking, for typical aircraft flyovers, the perceived noise level is approximately 13 dB greater than the 'A' weighted sound pressure level.)

4.3 The NNI was adopted by the Government for the assessment of noise around major airports and contours enclosing areas having specified NNI levels (or above) are regularly produced. These contours are produced by computer programmes and represent air traffic on a busy 12 hour summer day. The contours are then used to select criteria for acceptability. For example, the Greater London Council (GLC) guidelines suggest that the area within the 45 NNI contour is suitable for new dwellings only as infilling established residential areas. The area within the 60 NNI contour is considered definitely unsuitable for any dwellings. Furthermore, it is possible to select a particular contour e.g. 50 NNI, for the provision of noise insulation grants bearing in mind the costs of insulating large numbers of dwellings.

4.4 The particular dose-response relationship inplied in the NNI has been examined in a repeat survey at Heathrow in 1967 and in a number of studies at, or near, other airports. Although no compelling reason has emerged for changing the form of the NNI index, recent laboratory studies (Rice, 1977) have indicated that the number versus level trading relationship is more complex than the simple relationship implied in the 15 logN term in the NNI.

4.5 Furthermore, it is open to question whether the NNI

is applicable to a green-field site, although it may well correlate with response as well as any other known index. It is an index that is not intended to take account of the levels of other sources, which may or may not be important, and it is plainly not intended in any way to represent the dose-response relationships to other sources than aircraft noise.

4.6 Road traffic noise is currently assessed by using the L_{10} index; that is, the A-weighted sound pressure level exceeded for 10% of the time. The Noise Insulation Regulations 1973 specify a criterion level of 68 dB(A) L_{10} (18 hour), which is the arithmetic mean of the 18 hourly L_{10} levels covering the period 0600 to 2400. The L_{10} index was selected as a simpler alternative to the Traffic Noise Index (TNI) proposed by Griffiths and Langdon (1968) after a survey of 1400 residents of traffic noise exposed dwellings in London, and it was adopted at a time when simple machines for measuring Leq directly were not available.

4.7 The L_{10} index suffers from the inability to take account of either the peakiness of individual events above the L_{10} level, or the degree to which the steady background drops below the L_{10} level. It is possible to envisage situations which, although subjectively different, could have similar L_{10} levels. As such, it is an inappropriate index for use with situations other than road traffic and may not be suitable for situations where there is another noise source of comparable or higher levels than the road traffic noise.

4.8 The GLC guidelines take a different approach with regard to road traffic noise and specify indoor noise levels to be aimed at as acceptable criteria. Thus the architect is encouraged to design for a chosen indoor environment, irrespective of the outdoor noise levels. These guidelines are an internal L_{10} of 50 dB(A) in the daytime (0700 to 1900 hours) in living rooms, and 35 dB(A) in the evening (2200 to 2400 hours) in bedrooms. However, it is recognised that it may not always be possible to achieve these levels.

4.9 Industrial noise is commonly assessed in terms of BS4142: 1967 (amended 1975) (BSI, 1975) which is a procedure for comparing a corrected noise level (CNL) from the offending source with the background level. The difference is used to predict the likelihood of complaints on the premise that the greater the degree of intrusion above the background level the greater the likelihood of complaints. The procedure is straightforward and easy to apply and is a favourite amongst local authorities who often attempt to apply it outside of its brief (referring specifically to noise from factories, industrial premises, and to other fixed installations).

4.10 As a procedure, BS4142 is limited in application and may be inappropriate in complex environments including significant contributions from transportation noise sources. For example, were it to be erroneously applied to aircraft noise, it is likely that in many situations it would predict highly adverse community reactions where no such reactions occur and where the NNI levels are comparatively low.

4.11 The American Preferred Noise Critera (PNC) curves and the European Noise Rating (NR) curves are often used as an alternative to the dB(A) scale for evaluating indoor environments. The PNC and NR values are clearly specified in terms of appropriate indoor use at different levels and are useful for evaluating not only indoor dwelling noise levels but also industrial, office and other more or less sensitive premises. For example, it is suggested that Broadcasting studios should not exceed the 20 PNC curve (approximately 30 dB(A)) or the 15 NR curve whereas private offices may have internal noise levels up to the 30 to 40 PNC curves or the 40 NR curve.

4.12 However, the above two indoor criteria systems, again, may not adequately allow for the effects of a mixed noise environment where there may be a number of competing sources. In general, they are very useful for assistance in the design of ventilation and similar plant, and indoor/outdoor noise attenuation but they do not deal with perceived environmental quality and are of limited use in

the control of outdoor levels from transportation noise sources.

4.13 Finally, we come to the Equivalent Continuous Noise Level (Leq), an index which has a great deal of merit from the point of view of objective measurement, but which nevertheless should be used with caution from the point of view of predicting community response. The Leq unit is as fundamental to environmental noise as the kilowatt is to electric power, but taking the same analogy, just as the wattage of an appliance alone is not a sufficient description of that appliance, neither is the Leq alone a sufficient descriptor of any specific noise environment.

4.14 However, the Leq index has been used to select criteria for noise from Railway Traffic, Construction sites and Noise Abatement Zones. The GLC guidelines suggest some form of action where railway noise exceeds 65 dB(A) in term of 24 hour average Leq, (for example), and is supported in terms of using Leq by a recent national survey of railway noise annoyance. This survey found that the 24 hour Leq index is certainly as highly correlated with expressed annoyance as any other objective noise measure.

CONCLUSIONS

5.1 The current UK practice of defining environmental noise criteria in terms of perceived environmental quality, is probably the best way in which the problem could be tackled. The alternatives of using more objectively measurable human effects for the selection of criteria do not have as much appeal, given the present state of knowledge. However, this is not to say that the situation might not change if some method is found for relating such measures as, for example, physiologically measured sleep stage changes or long-term epidemiological effects to perceived environmental quality. Of course, such changes would require more research.

5.2 However, the current UK practice of separate indices for each offending noise source is not an ideal solution to the problem. Unfortunately, no completely comprehensive

unified index has yet been discovered, despite the early promise of Leq and its derivative, the Noise Pollution Level (Robinson, 1971). The best policy at the moment is to continue to use the existing UK indices within the framework of their legally defined applicability, although it must be admitted that any decision to apply these indices outside of the range of conditions which were included in their development is administratively convenient but not scientifically proven. Where "difficult" cases arise, for example, the complex noise environment existing around a major airport and including road traffic noise, railway noise, industrial noise and various forms of airport ground noise, as well as airborne aircraft noise, it is politic to include an objective assessment in terms of the Leq contributions from each source. Then the different noise sources can be compared and contrasted in the same unit, something which is very difficult when different indices are in use for each source. The overall assessment by the noise expert must then, in the present state of knowledge, include an element of professional subjectivity, taking into consideration not only separate assessments of each source considered alone in terms of its established index but also the Leq based contribution breakdown described above.

5.3 Where assessments must be made in respect of the complex situation outlined above, in terms of particularly sensitive aspects such as night-time noise, then consideration should be made of the degree of intrusion of offending noise events above the background noise level. Such an assessment would be complementary to whatever criteria may have been laid down in any particular case with respect to any single source considered alone.

5.4 Of course, not all situations are as complex as the example given, but it is as well to be aware of the capabilities and limitations of any tools that are available. It is to be hoped that further research, such as is being conducted at ISVR and other institutions, may shed some light on some of the difficulties referred to in previous sections of this paper.

REFERENCES

H. BASTENIER, W. KLOSTERKOETTER and J.B. LARGE, 1975. Environmental Quality of Life, Commission of the European Communities, Report EUR 5398e. Damage and annoyance caused by noise.

BRITISH STANDARDS INSTITUTION 1967. BS 4197: 1967. A precision sound level meter.

BRITISH STANDARDS INSTITUTION 1975. BS 4142: 1967 Amended 1975. Method of rating industrial noise affecting mixed residential and industrial areas.

J.M. FIELDS and J.G. WALKER 1980, Institute of Sound and Vibration Research, University of Southampton. ISVR Technical Report No. 102. Reactions to railway noise: a survey near railway lines in Great Britain.

J.M. FIELDS and J.G. WALKER 1979. Unpublished data.

I.D. GRIFFITHS AND F.J. LANGDON 1968. J. Sound Vib. Vol. 8(1) 16-32, Subjective response to road traffic noise.

J.B. LARGE, C.G. RICE, J.G. WALKER AND J.M. FIELDS 1978. Paper presented at the Noise Advisory Council Seminar, Darlington, Sept. 5-7. Noise research and criteria.

J.D. MILLER 1971. US Environmental Protection Agency NTID 300.7 Effects of noise on people.

NOISE INSULATION REGULATIONS 1973. Statutory Instruments 1973, No. 1363.

OFFICE OF POPULATION CENSUSES AND SURVEYS 1971. Second survey of aircraft noise annoyance around London (Heathrow) Airport. HMSO, London.

C.A. POWELL 1979. NASA Technical Paper 1479. A summation and inhibition model of annoyance response to multiple community noise sources.

C.G. RICE 1977. J. Sound Vib., Vol. 52(3), 325-344. Investigation of the trade-off effects of aircraft noise and number.

D.W. ROBINSON 1971. J. Sound Vib., Vol. 14(3), 279-298. Towards a unified system of noise assessment.

M. VERNET 1979. J. Sound Vib., Vol. 66(3), 483-492.
Effect of train noise on sleep for people living in houses bordering the railway line.

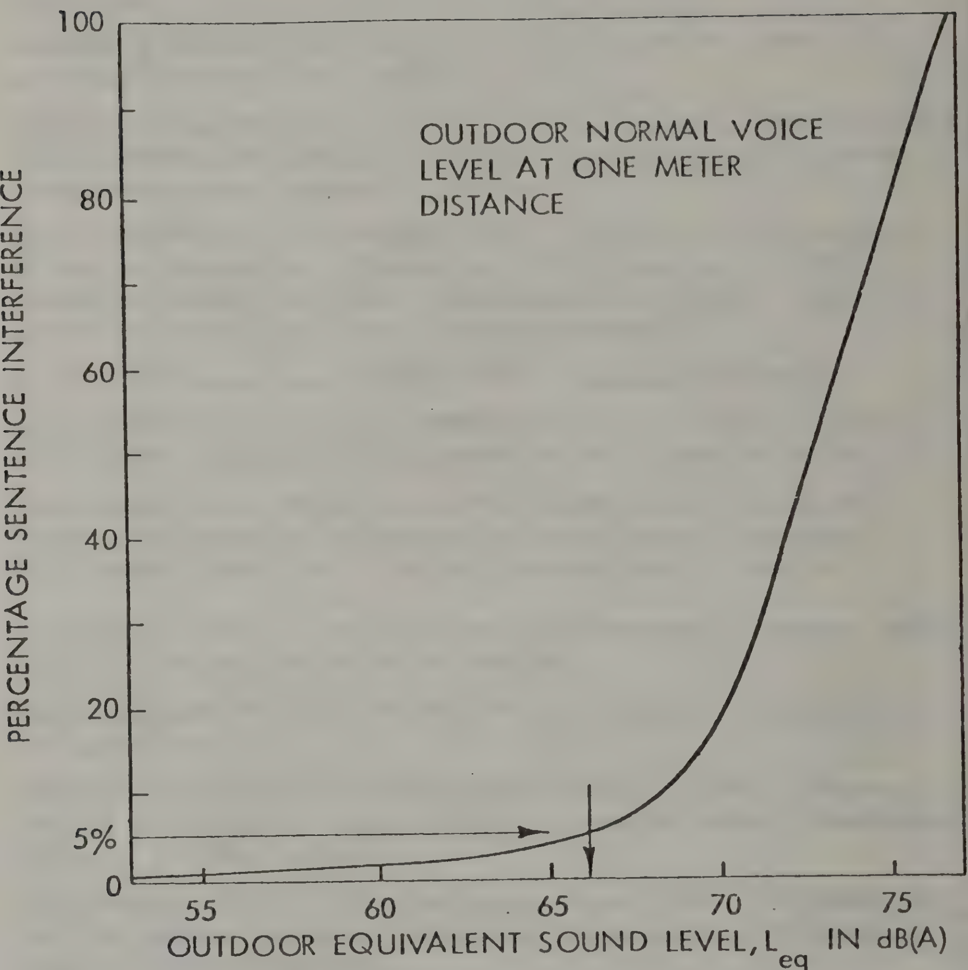


FIG. 1 PERCENTAGE SENTENCE INTERFERENCE AS A FUNCTION OF OUTDOOR EQUIVALENT SOUND LEVEL, L_{eq} IN dB(A) (AFTER MILLER (1971))

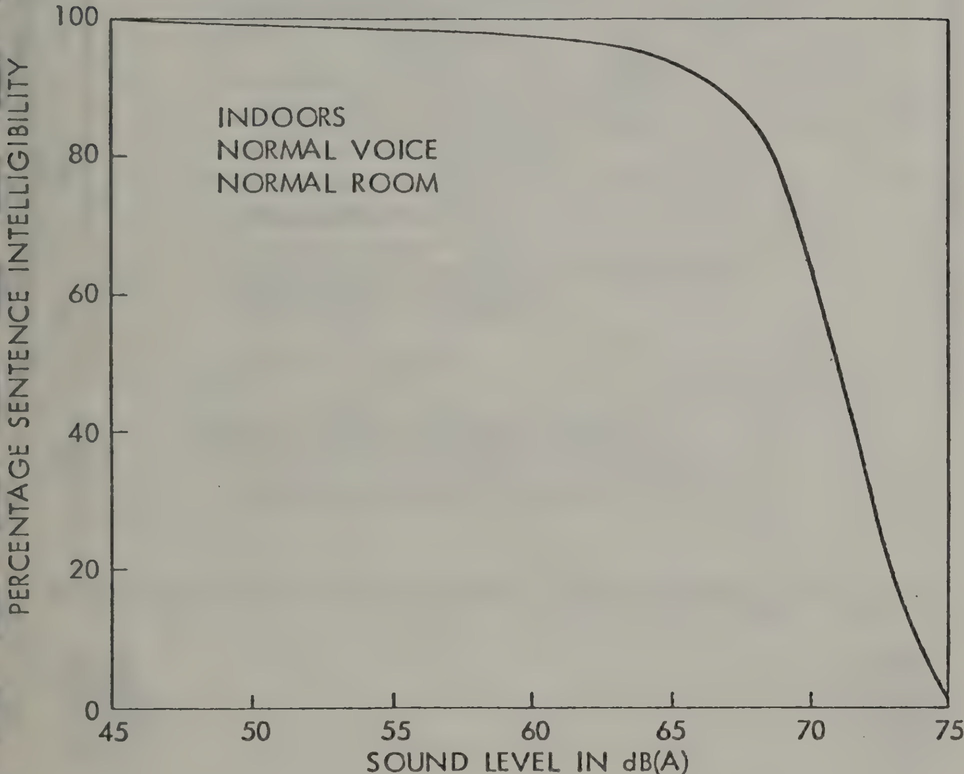


FIG. 2 SENTENCE INTELLIGIBILITY AS A FUNCTION OF SOUND LEVEL FOR NORMAL VOICE IN THE INDOOR SITUATION

RELAXED CONVERSATION WOULD BE 10 dB LOWER (AFTER MILLER (1971))

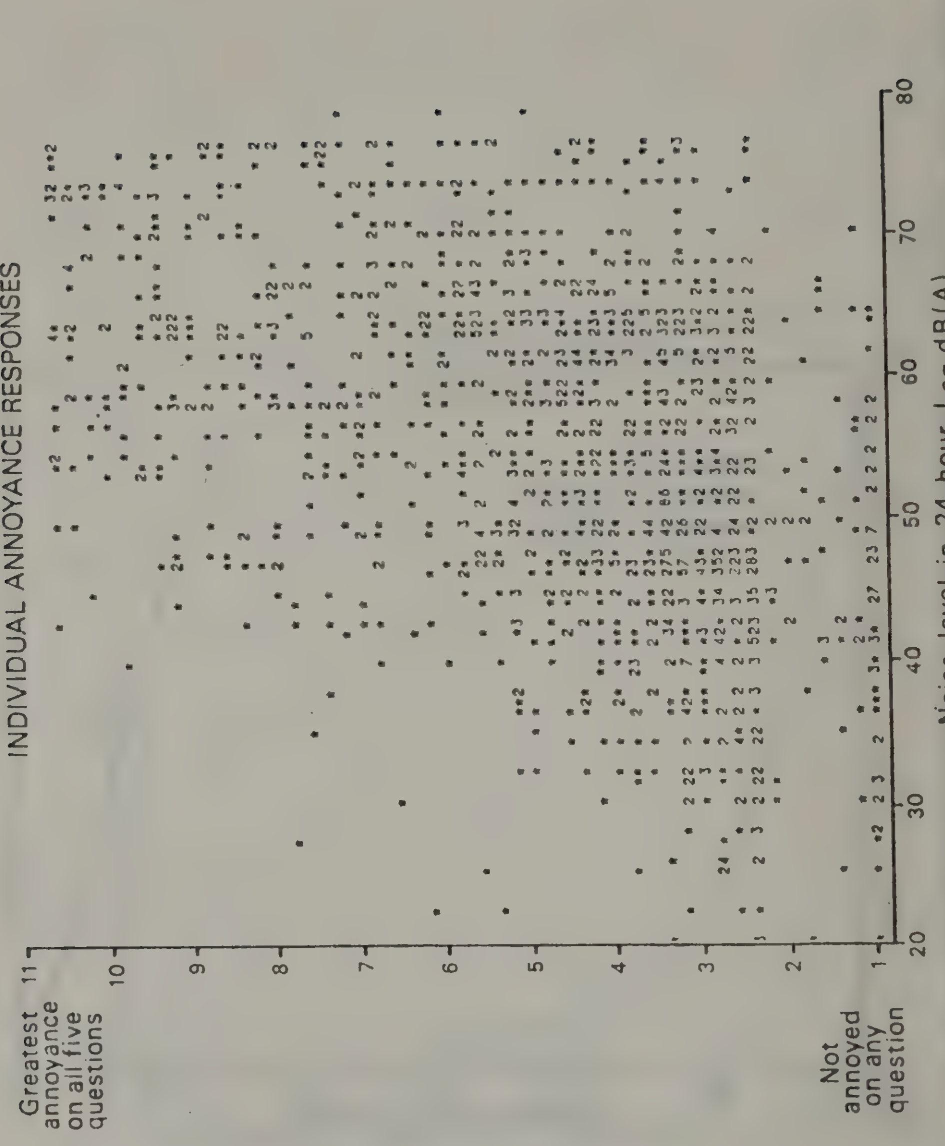


FIG. 3 INDIVIDUALS' ANNOYANCE SCORE AGAINST RAILWAY NOISE LEVEL
(FIELDS AND WALKER, 1979)

NATIONAL SOCIETY FOR CLEAN AIR

47th ANNUAL CONFERENCE
22 - 25 SEPTEMBER 1980
BOURNEMOUTH

THE ROLE OF THE LOCAL AUTHORITY IN THE CONTROL OF NOISE

by

G.R. Charnley, B.Sc.(Hons.)
Assistant City Health Officer,
Southampton City Council

National Society for Clean Air
136 North Street
Brighton BN1 1RG
England

I should perhaps firstly point out that any views expressed in this paper are my own views and are not necessarily those of the Southampton City Council.

While noise can be defined in general terms as unwanted sound, increased environmental awareness amongst members of the public has led, in more recent years, to the two words - noise and sound - being regarded as synonymous. Perhaps the noise educationalists have gone too far; the noises we used to hear and which used not to bother us at all we are now told to listen to and, when we do, our ears latch on to them and we find them distasteful.

Hopefully, the attitude we are all seeking to engender is one of striking a balance in the noise environment; some noise is inevitable if the wheels of industry are to remain turning, and are to be encouraged to turn, whereas society cannot afford unnecessary noise. A sprinkling of noise of the right kind can also add spice to an otherwise monotonous acoustic environment.

I recently received a complaint about pop music being played in a boutique in the shopping precinct. The complainant had been out shopping and he could clearly hear the music across the road; that was, between the traffic noise crescendos. Had the music been by Sibelius, the complaint would probably not even have arisen! Quite by coincidence, Radio Solent had only recently carried out a survey during the summer months outside another boutique where the music was clearly audible to passers-by. None of the public interviewed was concerned about the music - many not having even noticed it until it was brought to their attention. The majority were seemingly unconcerned, and a minority actually expressed a liking for it.

In the particular case complained of, no actual nuisance, in the legal sense, was being caused, and neither were any of the byelaws being contravened. So I had a long, hard, philosophical think, and came to the following conclusion; contrasting the live noise scene in the city streets perhaps one hundred or so years ago, with the clatter of horses' hooves, the sounds of street criers, barrel organs and so on,

there would be very little left to stimulate the auditory senses in the High Street nowadays were sounds, such as music from boutiques, eradicated. An intermittent car horn and the bleep of the pelican crossing would be among the few remaining stimuli audible above the dull roar of traffic.

I have so far tried briefly to set the scene within which society seeks to plan for its future noise environment, and to control and eliminate unnecessary noise. Much of the noise in our environment is produced locally and, quite naturally, Local Government takes the lion's share under its control. Elected members and officers in Local Government are very much involved at grass roots level with the public, as well as industry and commerce, and are perhaps in a better position to interpret local needs and economics on a local basis with greater sensitivity.

Consider, for example, a planning application for a proposed industrial development. What sort of noise levels should the local community be prepared to accept from that development if it is permitted to go ahead? I think that the mere absence of a statutory noise nuisance would not in any way constitute an acceptable planning objective because, in this case, the objective would merely be the limit of the acceptable rather than the desirable. On the other hand, the complete absence of noise from the development is most unlikely to be achieved and may be economically non-viable. Inevitably, therefore, agreement will be reached between the developer and the planner in the grey areas between the two extremes, in many cases at what may be described as the optimum level of control; that is the point where the law of diminishing marginal returns begins to operate.

The U.K. approach to pollution control has for many years been along the lines of requiring the best practicable means to be employed in an endeavour to permit maximum flexibility in locating a new development in the existing locality. The b.p.m. approach is often complemented by guidelines which may or may not have been formally adopted by local authorities, and such guidelines aim at achieving a degree of uniformity which, along with flexibility, is demanded by the developer. The pragmatic approach being

adopted by the E.E.C. may result in dragging recalcitrant countries (where little, if any, regard is paid to pollution control) out of their stupor but, I feel, will only serve to hinder progress both environmentally and economically, in countries already adopting a more responsible approach.

The Environmental Health Officers' Association statistics show that industrial and domestic noise are the main sources of complaint from the public received by Local Authorities whilst, it is interesting to note, that traffic noise was elicited as by far the greatest source of noise nuisance by respondents in the social surveys undertaken as part of the Darlington Quiet Town experiment. Perhaps we exhibit a tacit acceptance of the traffic noise problem because it seems natural to assume that very little, if anything, can be done to resolve it.

The Highways Authority, together with County and Local Planning Authorities, structure our road networks by implementing policies laid down in Structure Plans and Local Plans, together with roads and transportation policies. Such policies are produced at a local level with public involvement but are also integrated with both national and regional strategy. Tackling traffic noise at the design stage can significantly reduce its impact on the local environment by such measures as noise barriers, earth mounds, road surface design and free-flow design. The actual route followed by a new road cannot always be varied but, of course, this aspect and the best use of topographical features can also lead to significant noise reduction. The Heavy Commercial Vehicles (Controls and Regulations) Act 1973 gave Local Authorities the power to designate through routes for heavy commercial vehicles, and also to create zones in which the use of heavy commercial vehicles is prohibited.

Where new highways or additional carriageways to existing highways are constructed and the traffic noise is predicted to exceed a specified level within fifteen years from the opening of the highway or additional carriageway, the Noise Insulation Regulations made under the Land Compensation Act 1973 require the Highway Authority to carry out or make a grant available towards the cost of carrying out noise

insulation work at residential property affected. The insulation work consists of the provision of acoustic double glazing, white venetian blinds to counter solar heat gain, and special ventilator units, the measures being provided in living rooms and bedrooms only. Such insulation does not, of course, in any way improve the noise climate in gardens and communal areas adjacent to the properties affected, and another quite often significant ramification is that in the case of flats and other attached properties, internal ambient noise levels are reduced by up to 30dB(A) which then makes noise from neighbours far more intrusive. Discretionary powers are also given in the regulations for noise insulation to be carried out in certain other cases which may include construction work noise.

The traffic noise level specified in the Regulations above which one may qualify for insulation is set at an L10 18-hour value of 68dB(A). Social surveys have shown that well over 40% of the public exposed to this sort of noise level is dissatisfied. It is also worthy of note that, even where huge increases in traffic occur along existing roads or even, for example, where through routes are designated for heavy commercial vehicles, residential property would not qualify for sound insulation. Only public pressure and informed argument is likely to redress this situation and, even then, only when finance becomes available.

The planning policies of Local Authorities are probably, or at least have the potential to be, the most effective means of attacking unwanted noise; before it even arises. The technology has arrived; all that is needed is its application.

A Department of the Environment circular (10/73 Planning and Noise) told us in 1973 that we should separate industry from housing, and now we are being told to press ahead and encourage industrial development and, wherever possible, to integrate industry with residential and other development. Such integration of suitable industry is certainly viable, but calls for very careful consideration of each planning application. In most Local Authorities, at this stage, the Development Control Officer in the Planning Department liaises closely with the Environmental Health Officer in the

assessment of the noise and pollution impact of the proposed development. Close attention is paid at this point to pre-development site noise levels, likely future developments in the locality, topographical features of the area, proposed building structure and layout, type of process, transport arrangements, staff car parking and so on. Close consultation follows with the applicants and, in a number of cases, the advice of an Acoustic Consultant is recommended. In Southampton, considerable emphasis is laid on the need to resolve possible problems, and especially those of a technical nature, before the application is placed before Planning Committee. It is, of course, important for the Local Authority not only to consider the suitable location of noise emitters in its area, but also to give due consideration to the acceptable siting of noise sensitive development.

In many cases it is possible, with workable planning consent conditions, to integrate different types of development. Temporary planning permission can also be a useful planning tool where it is difficult to quantify the likely impact of certain developments at the planning application stage. Essentially, planning permission is required for the development of land where "development" is defined in the Town and Country Planning Act 1971 as "the carrying out of building, engineering, mining or other operations in, on, over or under land, or the making of any material change in use of buildings or other land". Intensification of use may constitute material change in use, but it is often very difficult to prove in practice. There are two main exceptions to the requirement for planning permission, namely where the works involved are covered by classes of development specified in the Town and Country Planning General Development Order 1973 which relates to small extensions, temporary buildings, certain agricultural buildings, and so on. The other main exception is where the change of use of a building or of land is within the same "use class" as specified in the Town and Country Planning (Use Classes) Order 1972.

Development can be controlled to some extent by only permitting uses covered by the Order where, for example, a light industrial building is defined as "an industrial building

(not being a special industrial building) in which the process is carried on or the machinery installed are such as could be carried on or installed in any residential area without detriment to the amenity of that area by reason of noise, vibration, smell, fumes, smoke, soot, ash, dust or grit". General industrial buildings and special industrial buildings are also covered by the Use Classes Order. It is often found, in practice, that the use of this classification is not tight enough to adequately control noise emission from new development, and a far more objective approach need be applied, such as the use of consent conditions.

Some developments which do not require planning permission may require approval under the Building Regulations and may be "caught in the net" at this stage. However, there are many developments carried out where the Local Authority neither has any legal input nor any opportunity to make any comments in relation to their environmental suitability, and which do create creeping increases in ambient noise levels. A number of measures are available to Local Authorities to control noise levels and reduce unsatisfactory noise levels before they actually give rise to nuisance.

In a number of Local Authorities, committees have been established on which industrialists, Local Government Officers and Members and other Pollution Control Agencies are represented, the general aim of which is to actively promote social accountability or social awareness amongst industrialists in their attitudes towards the environment. In Coventry, for example, Environmental Health Officers carry out "social audits" of industrial premises, taking a close look not only at noise levels but at all pollution sources and activities associated with each premises. A report is then presented to the industrialist concerned, highlighting areas in which it is felt that environmental improvements should be achieved, following which the industrialist is expected to draw up a schedule of work and time objectives within which that work is to be carried out to secure the improvements. This approach stimulates forward planning towards an improved environment for implementation over a period of years if necessary, and also encourages the placing of environmental impact at the top of

the list when considering any future development proposals. Having worked in Coventry a few years ago, I can vouch for the cost effectiveness of such an approach by Environmental Health Departments, where the creeping pollution situation has arisen or is likely to arise.

Where the force of reasoned argument fails to persuade the noise polluter to improve his social conscience, then the noise abatement zone procedure is available under the Control of Pollution Act 1974. The concept of being able to control and reduce noise levels by this means is good in essence, but the methodology in practice provides a clumsy method of measuring and controlling sound where noise is the actual problem. From the staffing and equipment aspects, the demands on resource are highly intensive to follow the laid down procedures adequately. Noise abatement zoning may leave in its trail a legacy of monitoring and, not only that, but also, possibly, a large amount of unplanned work in dealing with applications for permission to increase registered levels. To date, only 31 Noise Abatement Zones have been confirmed in England and Wales since the Control of Pollution Act 1974 came into operation, and very few of the larger urban authorities, where one might expect to find the majority of noise problems, have declared any zones; one can only pose the question as to why this is so? Noise abatement zoning has yet to be tested in the law courts when, no doubt, acousticians will have a field day! Having briefly described the Local Authority's role in the two areas of prevention at the design stage and control in the operative stage, let me now turn to the abatement of noise where it has become, or is likely to become, a nuisance.

Part 3 of the Control of Pollution Act 1974 became operative on 1st January 1976. In addition to the Noise Abatement Zone Provisions just described, the Act makes provision for the abatement of noise nuisance, the abatement and control of noise on construction and demolition sites, the operation of loudspeakers in streets is restricted and provision is also made for the Secretary of State to make regulations limiting and controlling noise from various plant and machinery, although none has so far been forthcoming. The noise provisions of the Control of Pollution Act are generally administered by the Environmental Health Departments of Local

Authorities, largely because the Environmental Health Officer has grown up with nuisance abatement and pollution control and perhaps, even more important, in dealing directly with members of the public over a great many years.

A mandatory duty is placed on every Local Authority to actively deal with nuisance problems and also to formulate policy in relation to Noise Abatement Zones. The first of these duties relating to statutory nuisance is probably fulfilled by most Local Authorities by investigating all noise and vibration complaints brought either directly or indirectly to its attention. With so much other legislation to enforce in the Housing, Food Hygiene, Health and Safety at Work, Public Health and Atmospheric Pollution fields, priorities, quite naturally, have to be established, which inevitably means that the thin red line becomes rather stretched in the creation of a "cordon sanitaire".

The net result, much to the relief of the ratepayers no doubt, is that it is difficult to warrant the establishment of nomadic sanitary policemen for the detection of noise nuisances.

Noise nuisance complaints are received by Environmental Health Departments directly, sometimes through the Ward Councillor, sometimes anonymously, and perhaps, more common nowadays, by way of petition. People signing noise petitions quite often range from the hypersensitive to those merely wishing to hurry the petitioner from the front doorstep. On one occasion, an elderly lady who was deaf had signed the petition. It is quite often the case that few of the petitioners are materially affected by the noise source or sources which gave rise to the petition.

Taking as an example noise from an industrial or commercial source, the Environmental Health Officer would first visit the complainant and establish relevant details pertaining to the complaint, such as when it first started, the character of the noise, the times of day or night at which it occurred, and the actual way it was interfering with the complainant in the enjoyment of his or her property. In law, for anything to constitute a nuisance, the matter complained of must be

more than a mere annoyance, but must constitute material and substantial interference to an occupier. The Officer would usually visit the complainant's property during these times when the noise complained of was occurring, and would assess the situation by ear and would probably take sound level readings of the noise emitted. The Officer would then form in his own mind an opinion as to whether he could substantiate a nuisance or otherwise, and would inform the complainant accordingly. If, in the Officer's opinion, a nuisance did exist, he would then contact the person responsible for the noise emission, then probably explain the full legal position to that person and discuss possible steps which might be taken to abate the nuisance. At this point, a recommendation is sometimes made that the person emitting the noise should engage the services of an acoustic consultant. Quite often, however, it is possible to mitigate the nuisance by relatively straightforward means such as restricting hours of operation, providing simple barriers and so on. From here, remedial works would normally be agreed to be implemented within an appropriate time-scale, and a legal notice would be formally served by the Local Authority as required by the Act. Some noise complaints can take many months to resolve, and it is surprising to find the amount of tolerance that can be shown by complainants during that period provided they are kept adequately informed of the state of progress and assured that steps are actively underway to resolve the problem.

In the case of trade or business premises, it is a defence to prove that the best practicable means have been used for preventing or for counteracting the effect of the noise, where financial implications, local conditions and circumstances, and the current state of technical knowledge have a direct bearing.

Next door neighbour type complaints are generally difficult to resolve. The action which initiates the noise complaint is often far removed from noise itself; for example, the football continually coming over the garden fence onto Mr. Smith's prize roses, causing Mr. Smith to take a lot less care over the noise he makes whilst constructing his "do-it-yourself" furniture in his garden shed. It is rarely

possible for an E.H.O. to be at the scene at the time the incident occurs, unlike the "Bank Manager in the cupboard" and quite often the facts, as given by Mr. Smith, contradict those given by Mr. Jones and vice versa. The Control of Pollution Act has made provision for such circumstances in permitting an individual occupier to initiate his own action through the Magistrates' Court.

Construction and demolition site work, which also includes dredging, works of engineering and road building and repair, can be controlled under the Act either by service of notice by the Local Authority, or by the person intending to carry out construction works applying for prior consent. Any notice served may specify the type of plant or machinery to be used or prohibited, it may specify the hours during which the work can be carried out, and also the levels of noise which may be emitted from the construction site and may also provide for any change of circumstances (e.g. in cases of emergency). Here again emphasis is laid on the need to ensure that the best practicable means are employed to minimise the noise.

With certain exceptions, for example the use of a car horn, the Act prohibits the use of loudspeakers in streets between 9 o'clock in the evening and 8 o'clock on the following morning for any purpose. It also prohibits their use at any other time for the purpose of advertising any entertainment, trade or business. It may be of passing interest to you to note that loudspeaker vans and cars used for electioneering purposes are not covered by the Act unless they are operated so as to give a reasonable cause for annoyance to persons in the vicinity! Ice-cream vans and other vehicles selling perishable foods are permitted to operate loudspeakers between noon and 7.00 in the evening.

Although the Control of Pollution Act makes provision for the abatement and prevention of noise nuisance from a wide variety of sources, noise from aircraft other than model aircraft is specifically excluded. The Local Authority input into aircraft noise control is generally limited to control at the planning stage of airport development and the location of suitably designed housing in areas substantially affected

by aircraft noise. Many airports have an Airport Consultative Committee on which airport management, local authority representatives, and representatives of groups of people affected by an airport operation are represented. Such committees monitor levels of airport activity, consider airport policy, and also act as intermediaries in the investigation of complaints.

Many Local Authority byelaws are still in force, which are generally based on model byelaws. Noisy hawking, the playing of music and radios in streets are commonly covered by bye-laws, and there are even model bye-laws in existence controlling the use of acoustic bird scaring devices. The latter model bye-laws prohibit the use of acoustic bird scarers between sunset and sunrise; those who drafted this particular model bye-law were obviously late risers, having failed to note that the sun rises before 4.30 a.m. during the season of the year when bird scarers are a necessity!

Finally, having looked into local authority activity in the prevention, control and abatement of noise, a further important area of noise control must not be forgotten - namely workplace noise.

Local Authority Environmental Health Officers are responsible for the enforcement of the Health and Safety at Work Etc. Act 1974, and its relevant provisions which includes the Factories Act 1961 and the Officers, Shops and Railway Premises Act 1963, in approximately 720,000 premises. These premises include catering premises, public houses, offices, shops, warehouses and a significant number of smaller factory premises. The embodying Act makes it the duty of every employer to ensure, so far as is reasonably practicable, the health, safety and welfare at work of all his employees. Hazardous noise levels are not uncommon in a number of work areas covered by Local Authority enforcement staff, and noise below health hazard levels needs also to be carefully considered from the welfare aspect in many office premises especially where computers, automatic typewriters, photocopying machinery, etc., are in common use.

Although by no means complete, I have tried in this paper to

give an insight into the work undertaken by Local Authorities in the creation of an acceptable noise environment.

The system of noise control at Local Authority level, whilst not being perfect, does possess the sensitivity, awareness of local environment and accessibility for the developer and the ratepayer, so sadly lacking in centralised and even regional control organisations. The present government is putting forward policies aimed at setting up Urban Development Corporations and Enterprise Free Zones. They have said, on the one hand, that pollution and health and safety aspects will not be relaxed.

On the other hand, however, following the decision to build a fourth air terminal at Heathrow "in the national interest", the Secretaries of State for the Environment and Trade, though recognising the airport's environmental impact, have decided not to adopt several protective measures. These measures include a ceiling of 260,000 air traffic movements per year at Heathrow which, instead, will be increased to 275,000 to allow "effective use of the airport's resources" and also soundproofing for schools and hospitals is dismissed "bearing in mind the resources likely to be available".

Too many controls stifle the economy, stereotype environments and are inflexible; inadequate control measures in the past have led to the scars which we are still today endeavouring to heal. One cannot ignore, however, that the national economic cake is becoming smaller as is the noise and pollution control slice, and this must be reflected at local authority level by improving effectiveness. Professor Sir Louis Matheson, at the 150th Anniversary of the Royal Charter, Institution of Civil Engineers, said "Engineers will have to learn how to function in a world which no longer accepts their work as automatically desirable. They will have to be technically competent, economically convincing, ecologically sensitive, environmentally literate and politically adept"; are we not all, to a degree, engineers of the society in which we live?

NATIONAL SOCIETY FOR CLEAN AIR

47th CLEAN AIR CONFERENCE
22 - 25 SEPTEMBER 1980
BOURNEMOUTH

COMMUNITY RESPONSE TO NOISE

by

C.R. Cresswell
Environmental Health Officer,
Newcastle upon Tyne

National Society for Clean Air
136 North Street
Brighton BN1 1RG
England

As the response to noise is subjective and the word "community" covers such a wide variety of interests, it is impossible for one person to do justice to this subject. The observations expressed in the paper are personal ones about the community response to certain aspects of noise and reflect my experiences and opinions. Other people's experiences will no doubt differ from mine and, in consequence, they may with justification disagree with what I have to say.

The general public do not see noise as a health hazard and few appear to have realised how much pleasanter life could be for the majority if noise levels were reduced. As with other aspects of environmental health, such as air pollution and food hygiene, interest only seems to be aroused when the individual is personally affected in some way or other. However, noise is a subject about which people frequently display idle curiosity. For example, if asked what one's job is when enjoying the nightly visit to 'the local', the answer "noise control" excites more interest than air pollution control, and the questioner often has some small anecdote involving noise which he is prepared to recount.

A great deal has been written and said about the Darlington Quiet Town experiment and there is certainly nothing new that I could add. The two year experiment highlighted some of the problems involved in trying to get the public interested. It is a matter for speculation whether a more fruitful response might not be gained by holding an annual 'quiet week'. Such an event would not entail so much expense and effort, the approach and tactics involved could be modified each year in the light of the experience gained and the exercise act as a regular reminder to everyone that noise is a form of pollution deserving consideration.

The domestic noise problem, or the noise which affects people in their homes, varies throughout the country depending upon whether one is talking about city, urban or rural life and also, to some extent, upon the habits and customs of the people living in the area. As part of the pleasure of living in the country involves the sounds associated with nature and agricultural activities, the rural community are generally more responsive to noise than town dwellers. Passing air-

craft and cars are much more likely to be noticed and cause offence than they would in the town.

The country is not, however entirely free from obtrusive noises. Bird scarers, for example, can give rise to problems, particularly when situated close to houses and left to operate throughout the night. The Department of the Environment circulated a consultative paper in 1976 outlining a proposed Code of Practice which, amongst other things, claimed these devices were indispensible and no suitable alternative was available. I understand that some of the suggestions included in the paper provoked a considerable response both from organisations representing farmers and horticulturists as well as local authorities seeking to protect the rate-payers. In any event, a second consultative paper has not been issued and so far as the DOE are concerned, the sufferers have been left 'to grin and bear it'. It is also worth noting that the Royal Commission on Environmental Pollution did not rate noise worthy of a mention in their seventh report 'Agriculture and Pollution', although they were not so reticent on the subject in earlier reports.

Opencast mining is another noisy type of operation which has affected many country dwellers, particularly in the north east of England. One of the largest and possibly most environmentally sensitive opencast sites is at Butterwell near Morpeth, Northumberland. Coal is now being produced from this site, but two long, fiercely contested public inquiries were necessary before permission to proceed was granted. Noise implications were one of the major considerations and conditions governing noise levels were attached to the consent. The local resistance was intense, holding up development for years and adding considerably to the N.C.B. costs. Eventually approximately £100,000 had to be spent on noise suppression of mechanical plant alone.

People living in urban communities with a large immigrant or student population have had to get used to a more noisy environment. The West Indians in particular produce a lot of noise when enjoying themselves with such things as late night parties involving lots of people and loud music. The

difference between the West Indian and English attitude to noise is also apparent to anyone watching cricket on television. If the crowd contains a number of West Indian spectators, one can guarantee it will be noisy. The noise is apparently good humoured and the cricket would be spoilt for the West Indian if he could not express his feelings in a noisy manner. On occasions like this the noise may add to the average Englishman's enjoyment, particularly if it is a limited over game being watched on the television, but to sit through the same amount of noise at a five day Test Match would no doubt produce a different reaction.

Most young people today seem to find it necessary to have a musical accompaniment provided by a transistor radio or record player in order to do their homework and it is said that music aids concentration by blotting out other noises. Suggestions that concentration might in fact be easier without the musical background, the rate of work speeded up or the quality improved meet with looks of incredulous disbelief. However, I have noted in the case of my own son, now an undergraduate, that as the work has got harder, and the pressure to do well increased, he has gradually come around to working without music.

Surveys of people living in terraced or semi-detached houses showed that although less than 10% of the population are likely to be bothered by neighbours' noise, it is, nevertheless, the most widespread reported form of noise nuisance. For the purposes of comparison with others sources it must be borne in mind, however, that the number of people potentially exposed to this type of nuisance is larger than for other noise nuisances.

The arrival of a more affluent society is responsible for an increased number of internal domestic noise problems, although changes in furnishings such as wall to wall carpeting throughout may lessen the effects to some extent. Many more people can afford to install relatively expensive hi-fi systems which are sufficiently powerful to disturb neighbours. A large number of households, where husband and wife go out to work, keep a dog which is shut up all day and frequently barks. A great deal of housework and do-it-

yourself is done at nights and weekends and some of the equipment used can be noisy. Once again using my own experience as an example to illustrate the point, our current highly efficient electric carpet sweeper produces 88 dBA at 1 metre compared with the 75 dBA produced by its less efficient predecessor. A further source of internal domestic noise, now more noticeable, is the plumbing system where the widespread use of copper produces far more noise than the no longer acceptable lead systems commonly used.

The poor overall sound insulation performance of many dwellings found by the Building Research Establishment must increase the aggravation created by some of these noises. The time is surely here when the purchaser of a new house should have the right to request a builder to guarantee that the property complies with the requirements of the Building Regulations.

When it comes to the social side of life, today's younger generation in particular appear to find noise more of a necessary adjunct to whatever they are doing than used to be the case. The Friday night hop at the local church institute aided by Victor Sylvester records or a three piece band has given way to the noisy two or three times a week discotheque. Although many of these gatherings now take place in premises which have either been purpose built or specially adapted and, therefore, create less nuisance than a few years ago to the inhabitants of the neighbourhood, the same cannot be said of the adjacent car parks. The noise a relatively large group of people leaving a discotheque or public house late at night makes frequently causes concern to local residents and little apparently can be done to minimise the nuisance.

Moving on to another source of noise, the burglar alarm, which causes more of a problem than many people realise. The first approaches about the prolonged and/or frequent ringing of an alarm are normally made to the police and it is only when the local environmental health department has been particularly active or the individual is at his wit's end in desiring something done that complaints reach the local authority.

People should be free to protect their property against burglars by any reasonable means available. However, it seems wrong to do this by deliberately causing a nuisance, irritation or annoyance to people living or working in the vicinity and, in many instances, to rely on the self same people to notify the police or, more rarely, the key holder. I cannot recall a single case where a person notifying the police about an alarm being activated has later been thanked for his trouble by the occupier of the property being protected.

The attitude of the police to burglar alarms which have been triggered off also leaves a lot to be desired. Once they have satisfied themselves that there has been no unlawful entry and an attempt made to contact the key holder by telephone, the police normally lose interest. They are quite prepared to allow an alarm to ring all night or weekend without endeavouring to insist that the key holder turns out. The rapid rate at which new alarms are being installed and the problems created by existing alarms demands that this source of noise nuisance should receive far more consideration than at present.

It has been said on numerous occasions that road traffic is the single largest source of noise which affects most people. The apparent inability of anyone to do much to reduce it was a weakness in the Darlington Quiet Town experiment and is a major problem in creating successful noise abatement zones. The Transport and Road Research Laboratory project to develop a quiet heavy vehicle has progressed satisfactorily, but even when the new vehicles are in production, it is difficult to foresee an overall improvement in the noise situation. The 10 dBA reduction gained, however, also applies to internal cab noise so that even if the general public are unaware of the progress being made, the vehicle drivers will derive some benefit.

The Chancellor's budget earlier this year provided some slight encouragement to those of us interested in reducing the noise from road traffic. The decrease in the road fund tax charged for electrically powered vehicles may only affect a limited number of vehicles at present, but it may,

if maintained, eventually persuade more people involved in local deliveries to change the type of vehicle used.

Traffic management schemes may offer a measure of relief in a few situations, but for practical purposes they have a limited value. There is frequently a conflict between vehicles and pedestrians which is difficult to solve, particularly in town centres. One answer has been to pedestrianise 'high streets', but this gives rise to delivery problems for shop keepers and can involve people in having to carry relatively heavy loads for considerable distances.

Noise is not seen as the most urgent problem when considering road traffic. Fuel economy and exhaust emissions are two of the things that appear to rank higher in people's list of priorities. There are, however, signs that with longer motorway journeys and higher average speeds, internal noise levels are beginning to be a factor taken into consideration when a new car is being purchased.

Pressure groups such as Friends of the Earth tend to concentrate their activities on other sources of pollution, such as lead emissions, rather than noise. We have one publicity seeking group at Newcastle (SLOGG) who have been campaigning for years to keep heavy lorries out of Gosforth and Gateshead. The organisers of the group also appear to concentrate most of their attack on possible effects of lead compounds emitted from vehicle exhausts rather than noise which, personally, I would have thought was much more of an annoyance and more damaging to the local environment.

A change in habits by a large proportion of the population involving less reliance on private cars and more use of public transport is a long term answer to road traffic noise, but there are no apparent signs of any such change taking place at the moment.

Rail noise does not appear to give rise to widespread concern, possibly because most railway lines have been in use for many years and people in the vicinity have grown used to the noise or were well aware of it when they moved in. Alterations in the type or frequency of the services

can however change the situation. The introduction of the 125 services has given rise to complaints in areas where rail traffic noise was apparently accepted without qualms before. The people of Newcastle and Tyneside will also have to face a new situation towards the end of this year when all the local lines are incorporated into a Metro system. Instead of having 20 or so trains per day passing at well spaced intervals there will be a 10 minute service in each direction from 5 a.m. lasting through to 1 a.m. the following day. This, together with the introduction of new sources of noise such as the public address system installed at each little station and the use of klaxons at road crossings, will produce additional pollution problems. It is difficult to forecast what public reaction may be as often people do not respond to new sources of noise in the way expected. For example, there was little interest in the opening up of a line to some steelworks after a gap of years until it became common knowledge that the valuation officer was prepared to reduce rateable values as a result of the noise and vibration caused by the trains.

The proposed introduction of a fourth terminal at Heathrow will no doubt be viewed with horror aggravated by the decision of the Secretaries of State for Environment and Trade not to implement many of the noise protection measures recommended by their inspectors. There is also a fear in the minds of many people who reside or work near the small provincial airports that as traffic increases there may be a tendency to divert more flights away from London to these airports. This would create problems as currently the only occasions when there is serious noise nuisance is at times that these airports are used for training flights. Such flights normally only last for 3 or 4 weeks each year and are tolerated because of the widespread belief that they are essential and the associated noise unavoidable. A second thought exercising the minds of some of these people is the possibility, in order to beat local road traffic bottlenecks, that more business men may be tempted to consider using a helicopter as a form of transport from the office to the airport.

The Health and Safety at Work Etc. Act 1974 has produced some

change in people's attitude to noise at work although, unless a fairly serious problem exists, it does not rate any action being taken. The attitude of employers and employees is understandable; redundancy and economic survival are of more importance in the immediate future. However, in industries with long standing noise problems firms have been pressurised by their insurance companies to protect workers in order to avoid the possibility of claims for compensation in respect of hearing damage.

The specific standards laid down under the Woodworking Machines Regulations 1974 have enabled Factory Inspectors to obtain improvements. Few firms, however, are prepared to pay out money for less noise in the absence of legislation and the chances of new legal powers in the foreseeable future are remote.

The general public appears to have little knowledge of, or interest in, noise abatement zones, while industry is gradually learning to be wary of the powers local authorities possess. Initially the average works engineer saw little danger to his operations, but once noise levels are registered he has found out there are problems. For example, if additional ventilation is required in any part of the factory, it is no longer possible to simply install an extract fan in the nearest wall or roof. This type of restraint and the limitation of a firm's ability to change their work pattern or alter buildings to suit new working arrangements was not foreseen, but may well in the future lead to more objections to Orders.

Some blame for the ignorance that persists about the subject of noise must lie with the education service. Little time appears to be devoted to sound when physics is being taught in schools. For example in the Tyneside Area 'O' level physics does not include any work on acoustics or sound and even at 'A' level, no more is taught than I was given in the 1930's up to School Certificate level.

It is now 20 years since we had the Noise Abatement Act but many architects, engineers and members of the police are still unaware that all local authorities have staff with

some knowledge of noise and many have specialist sections. Individual police constables are also frequently ignorant of byelaws made under the Local Government Act 1972 governing noise and which they are expected to enforce. Considerably more could be done to reduce noise and nuisance with improved co-operation between the police and local authorities.

As I said at the outset, any one person's observations on the community response to noise must be subjective and, therefore, not necessarily in accord with other people's views. However, I have tried to comment on what I believe to be the more important aspects of the subject and trust that delegates will find something of interest in what I have had to say.

NATIONAL SOCIETY FOR CLEAN AIR

47th ANNUAL CONFERENCE
22 - 25 SEPTEMBER 1980
BOURNEMOUTH

POLLUTION FROM ROAD VEHICLES

National Society for Clean Air
136 North Street
Brighton BN1 1RG
England

In 1975, in his Ditchley lecture, Lord Ashby suggested that there were three essential stages in the protection of man and his environment from any particular collection of pollutants. The first is the instinctive feeling of ordinary people that something is wrong and that it should be put right. This can lead to the second stage, if people's enthusiasm is sufficient, which is the mounting by Government of a detailed scientific and technical assessment of the complaints. In the third stage, the results of such investigations are passed back to the people through their elected representatives, whose function it is to examine the options defined in the second stage in the broader framework of what is possible and desirable both politically and economically. It is then possible to decide on the action to be taken.

The Society's new booklet on air pollution from motor traffic is concerned basically with the second stage of this process - the scientific and technical examination of the problem. However, the main reason for the booklet is that many ordinary people are concerned about traffic fumes and noise from traffic. The conclusions and recommendations reached on technical grounds state what the Society think can and should be done. Care has been taken in the preparation of the booklet to make the technical argument as clear as possible by avoiding unnecessary detail, but even more care has been taken to make certain that accuracy has not been sacrificed.

The booklet follows a logical development. First, the amounts of the various pollutants emitted by motor traffic are considered and then the concentrations of these pollutants found in streets are established. From this the possible effects on health and amenity can be examined. In order to be in a position to consider what technical means are practicable, or even possible, to reduce pollution from road vehicles, it is necessary to know in some detail how the various pollutants are produced in the different types of engine. This information is given so that the technical changes that have been enforced by law in the last few years may be appreciated as can the possibilities of further progress by such means.

However, at some stage it will probably be found that other

means such as suitable control of traffic flow or town planning may also be necessary, if pollution from traffic is to be reduced further. The motor car is an essential part of the present day social scene and the convenience and service which it provides far outweigh the disadvantages of the road congestion, air pollution and noise which it creates. Nevertheless as the number of road vehicles increases, restrictions on their use in city centres will almost certainly come about, as indeed they already have in some places.

It must also be accepted that methods of reducing pollution that involve alterations to motor cars which might make them less convenient to start, to drive, or even to maintain, will not be popular. For this reason, a brief mention only of the more acceptable alternatives that have been suggested for the motor car has been included.

Finally, noise. Noise from traffic can probably cause more serious deterioration of amenity and health than what might be termed the "conventional" pollutants. For this reason an important section on noise has been included at the end of the booklet, to give it emphasis.

The main conclusion reached is that the motor vehicle, as we now know it, is likely to be with us for some considerable time, and it is unlikely that the electric vehicle will replace the motor car, although it has potential of limited application e.g. for small delivery vehicles and the small vehicle for shopping. It also seems likely that petrol and diesel fuel are likely to remain the fuels to be used in vehicles with internal combustion engines.

However, one of the most important steps that can be taken to reduce pollution from spark ignition (petrol) engines is that such engines be properly maintained. In the meantime, the existing and proposed EEC Regulations appear to be sufficient to provide controls for petrol-engined vehicles used in this country and Europe. However, if it is subsequently shown that hydrocarbons and the oxides of nitrogen pose problems in Europe and the U.K., it may be necessary to fit catalytic converters or use modified engine designs.

The use of lead in petrol is an emotive subject. There is no doubt that lead is a cumulative poison and that its emission in any form to the environment should be reduced as far as is reasonably possible. Although the lead levels in petrol have been steadily reduced over the years, the amount of lead emitted from car exhausts has remained fairly constant since 1971 and it may even increase in the early 1980s because of more vehicles on the road. Many people would like to see the lead content of petrol reduced even further and the Society considers this to be prudent and supports this view.

So far as diesel engined vehicles are concerned, the main problem is still smoke. Although there are regulations, and although the position has improved in recent years, it is clear that many diesel vehicles do emit excessive smoke. We do not consider that the EEC Regulations are stringent enough, especially as the production control test is less exacting than that described by the type regulations. We also believe that there should be more stringent regulations imposed by the EEC with regard to gaseous emissions from diesel engines.

More should be done to reduce noise at source in all classes of vehicle, especially heavy vehicles at one end of the scale and motor cycles and mopeds at the other. We also believe that there is a need for the noise level of all vehicles to be tested regularly. Further, much more could be done with the control of traffic flow and the rerouting of through traffic clear of city centres. The greater use of pedestrian precincts which does much to reduce "conventional" pollution in city centres, can also help to reduce noise. We also believe that much more could be done to reduce the noise from the "bouncing" of heavy lorries over bad road surfaces by ensuring that roads are kept in better repair and that more attention should be paid to vehicle body design, to maintenance and operation of such vehicles.

Finally, we are strongly of the opinion that the present regulations regarding noise are too cumbersome and the police are therefore reluctant to spend the time which they require for other matters, in prosecuting offenders.

The Society's new publication "Pollution from Road Vehicles" is published by the Society at £2.50 (£2.85 to include postage and packing). The publication will be on sale at the Conference in Bournemouth at a special price to delegates of £2.00 per copy.

NATIONAL SOCIETY FOR CLEAN AIR

47th ANNUAL CONFERENCE
22 - 25 SEPTEMBER 1980
BOURNEMOUTH

THE EC DIRECTIVE ON SMOKE AND SULPHUR DIOXIDE: THE FUTURE FOR SMOKE CONTROL

by

P. Evans
Department of the Environment

National Society for Clean Air
136 North Street
Brighton BN1 1RG
England

The Clean Air Acts have been in force for nearly 25 years and considerable reductions in the concentrations both of smoke and sulphur dioxide have been brought about through the use of those powers. There is always the possibility that these great improvements will lead to some complacency about the need for the application of further smoke control. But two things are currently giving a new impetus and direction to smoke control: first, the recently adopted European Community Directive on standards for sulphur dioxide and suspended particulates and second, the changes being made to smoke control procedures by the Local Government Planning and Land (No. 2) Bill. Together these provide the need and the opportunity to take a fresh look at the way smoke control operates.

THE EUROPEAN COMMUNITY DIRECTIVE

The Directive has been under discussion for so long that its main provisions are reasonably well known; but, as it is now at last substantive Community law and, of course, binding on the United Kingdom it may be helpful to describe briefly the main provisions as finally agreed. The text of the main articles of the Directive is reproduced in Annex A. The agreement on the Directive was accompanied by a number of declaratory statements and these are reproduced in Annex B.

The core of the Directive is the limit values given in its Annex I. These are shown in a simplified form in Table I below. The Directive imposes an obligation (through article 2) on member states to ensure that these levels are not exceeded throughout their territory. We have, in the first instance, to attempt to achieve this by 1 April 1983 but where this proves impossible up to ten years may be allowed for the completion of the programmes of control (article 3) as specific limited areas.

The Directive also requires monitoring to be carried out where the limit values might be exceeded and prescribes the measuring techniques to be used. The coverage and methods of the National Survey are expected to meet these requirements.

THE DIRECTIVE AS AN AIR QUALITY STANDARD

One way to view the Directive is as the first air quality guideline, in fact an air quality standard. There is some flexibility over how and when it is reasonable to attempt to meet the standard; but it is now law. This represents a considerable change of emphasis from the present approach to the control of air pollution. The Royal Commission on Environmental Pollution in their Fifth Report (RCEP5) discussed the use of air quality guidelines and recommended their gradual adoption. Although there is as yet no formal Government response to that report, agreement to the Directive can be seen as de facto acceptance of the principle of an air quality approach. However the details of the approach have to be worked out and there are likely to be some differences from the method proposed in RCEP5.

The Directive is in essence a simple standard for air quality although the presentation tends to obscure this; there are to be mandatory standards (tha limit values) for the concentrations of the two pollutants considered together. Limits are specified for the concentrations measured over various periods of time to reflect the need to control the average level as well as the peak level of the pollutants. This linking of the acceptable levels and the concern with average and peak levels stems from the health evidence on which these standards are based. A simple way to view the standards is shown in Figure 1 where the SO_2 concentration and smoke concentration at sites are plotted against each other. The dashed line represents the Directive standard and the letters the values for some hypothetical sites. Sites A, B and C would be 'in breach' of the standard, whereas D, E and F would not. Given the year to year variability of pollution one might suggest that site G might be said to be 'at risk'.

These limits values correspond broadly in concept with the RCEP5 top level 'above which action should be taken to reduce concentrations'. (Figure 2). But the Royal Commission thought that these upper levels should not be fixed legal standards because ofthe complexity of enforcement that would follow. In practice although the Directive is a fixed

standard there is no intention to seek to control emissions on a short term basis to prevent breaches. The necessary action must inevitably be long term changes in controls or emission standards.

The guide values in the Directive are given as bands, largely because of the difficulty of determining precise values, and they do not correspond directly with either of the RCEP5 bands or with the 'lower limits'. They are available as reference points for various purposes and although they are close to being a 'lower limit', it is clear from Article 4.2 of the Directive that lower targets are thought of as possible in some cases.

Thus the air quality control system that will follow from the Directive is simpler than the proposals in RCEP5; in particular, there are no targets for different areas to aim at, simply a maximum that must not be exceeded.

IMPLEMENTATION

Air quality standards are a logical and intelligible way of expressing the ultimate objective of 'clean air' but they do not of themselves provide a simple guide to the control policy that must be adopted to meet them. The Royal Commission report acknowledged this difficulty and with the coming into force of the Directive the problem will need to be faced and the mechanisms that can be used in any areas exceeding the limit values settled in detail. The initial assumption is that no new primary legislation is needed and that some combination of the methods for which powers already exist will be sufficient. The main weapons are domestic smoke control, the control of industrial emissions whether through the local authority or the Alkali Inspectorate, and the control of the sulphur content of fuels.

A second set of values, guide values, are prescribed in Annex II of the Directive (Table 2). These can be used for a variety of purposes, including forming long term desirable goals (article 5) and providing alternative values for special zones (article 4). But none of these applications is mandatory.

TABLE 1

Limit Values for Smoke and Sulphur Dioxide in microgrammes per cubic metre

Period	Smoke*	Limit Values for Sulphur Dioxide
Year (median of daily values)	80 (68)	If smoke less than 40 : 120 If smoke more than 40 : 80
Winter (median of daily values Oct-March)	130 (111)	If smoke less than 60 : 180 If smoke more than 60 : 130
Year (Peak) (98 percentile of daily values)	250 (213)	If smoke less than 150 : 350 If smoke more than 150 : 250

* limit values for smoke relate to OECD method: figures in brackets give equivalents for BSI method as used in the National Survey.

The first task is of course the analysis of the extent and nature of any areas actually breaching or at risk of breaching the limits. Extensive analysis was carried out during the negotiations on the Directive, so that the extent of our obligation could be broadly but fairly reliably determined. But this analysis is now being extended with a view to identifying more precisely all local authorities containing areas at risk and specifying the type of risk in each case. The intention is not to prescribe what should be done in every area but to produce a basis for a dialogue with local authorities about the measures to be adopted.

There is one other aspect of the adoption of air quality guidelines that will merit wide discussion: the impact on

TABLE 2

Guide Values

Period	Smoke*	Sulphur Dioxide
Year (arithmetic mean of daily values)	40 to 60 (34 to 51)	40 to 60
24 hours (daily mean value)	100 to 150 (85 to 128)	100 to 150

* OECD method values: BSI values in brackets.

planning. New development almost inevitably means an increase in the amount of sulphur dioxide emitted. This may be minimal in the case of a housing estate heated by gas or more significant in the case of an industrial estate. Although the requirements for appropriate chimney heights should ensure adequate dispersion initially it might be that extensive new development would worsen the air quality in an area, either making it more difficult to attain the limit value for areas already in breach, or creating a breach where none existed. Planning, in the plan making rather than development control sense, could well have a role to play in dealing with any such problems that arose.

SMOKE CONTROL

As part of the Government's drive to remove inappropriate central controls over local authorities the Local Government Planning and Land No. 2 Bill contains amendments to the procedures for the confirmation of smoke control orders. The essential feature of the new procedure is that the Secretary of State will no longer confirm orders; local authorities will now be able to advertise and make orders without central intervention.

A whole set of administrative procedures had grown up around the statutory process of confirmation and these procedures have been carefully reviewed to see what needs to be changed to reflect the intention, as well as the letter, of the amendments being made by the Bill. The need to formulate programmes of action under the Directive has also been considered to see whether any further changes were required. No conclusions have been reached but it is possible to indicate some of the main lines of thought.

Apart from the present involvement with the confirmation of smoke control orders the Secretary of State is also concerned with the payment of grant for works of conversion. While such grants remain it is impossible to disengage entirely from local authorities' decisions on smoke control areas. There must be some means of predicting and, indeed, controlling the amount of central government expenditure on smoke control. One method of doing this would be to continue to require a local authority to seek financial approval before it made any smoke control order; it might be argued that this nullified the removal of the need for confirmation. There are alternatives: for example, one might aim to allow authorities to proceed with individual orders so long as certain prescribed criteria were met in each case and so long as the total expenditure committed in any year did not exceed a certain predetermined amount.

The analysis of the areas at risk under the Directive has shown that some areas currently breaching the limits are without extensive smoke control and bringing control into operation will be essential if those areas are to comply with the standards. One aspect of implementing the Directive is therefore likely to involve a more extensive use of the present returns from local authorities on their smoke control programmes. Initially this will allow the Department to assess the extent to which any derogations under the Directive might be needed and later to check if the required progress is being made. The obligation under the Directive are placed on national governments, but the only executive powers in this country are at one remove from the Department, mainly with local authorities. Any necessary improvements in air quality will have to be brought about mainly through a continuation

of the excellent cooperation with local government; although a reserve power for the Secretary of State to require the introduction of smoke control areas does exist.

It may be possible to combine these forward looking programmes needed for the purposes of the Directive with the overall control of spending on smoke control. The aim will certainly be to have a coherent integrated system imposing the minimum requirements on local authorities compatible with achieving the Community standards.

Given the need to continue with smoke control, particularly in specific areas in breach of the standards, the opportunity is being taken to consider all the administrative rules on smoke control grant to see if some of the more irksome anomalies can be removed.

CONCLUSION

The aim is to issue guidance on both the Directive and the revisions to smoke control in a circular later this year. But before then there will be detailed consultations with local authorities and others on all the proposals. Wide consultation and discussion are important in settling the direction that these aspects of air pollution control should take after the opportunity for change afforded by the Directive. This may well be as a significant turning point.

ANNEX A

Article 1

The purpose of this Directive is to fix limit values (Annex I) and guide values (Annex II) for sulphur dioxide and suspended particulates in the atmosphere and the conditions for their application in order to improve:

- the protection of human health;
- the protection of the environment.

Article 2

1. "Limit values" means:

- the concentrations of sulphur dioxide and suspended particulates considered simultaneously in accordance with Table A in Annex I and
- the concentrations of suspended particulates considered separately in accordance with Table B in Annex I,

which, in order to protect human health in particular, must not be exceeded throughout the territory of the Member States during specified periods and under the conditions laid down in the following Articles.

2. "Guide values" means the concentrations of sulphur dioxide and suspended particulates over specified periods which are given in Annex II and are intended to serve as:

- long term precautions for health and the environment;
- reference points for the establishment of specific schemes within zones determined by the Member States.

Article 3

1. Member States shall take appropriate measures to ensure that as from 1 April 1983 the concentrations of sulphur dioxide and suspended particulates in the atmosphere are not greater than the limit values given in Annex I, without prejudice to the following provisions.

2. Where a Member State considers that there is a likelihood that, despite the measures taken, the concentrations of sulphur dioxide and suspended particulates in the atmosphere might, after 1 April 1983, exceed in certain zones the limit values given in Annex I, it shall inform the Commission thereof before 1 October 1982.

It shall at the same time forward to the Commission plans for the progressive improvement of the quality of the air in those zones. These plans, drawn up on the basis of relevant information on the nature, origin and evolution of the pollution, shall describe in particular the measures taken or to be taken and the procedures implemented or to be implemented by the Member State concerned. These measures and procedures must bring the concentrations of sulphur dioxide and suspended particulates in the atmosphere within these zones to values below or equal to the limit values given in Annex I as soon as possible and by 1 April 1993 at the latest.

Article 4

1. In the zones in which the Member State concerned considers it necessary to limit or prevent a foreseeable increase in pollution by sulphur dioxide and suspended particulates in the wake of development, in particular urban or industrial development, the Member State shall, taking the guide values in Annex II as a reference point, fix values which must be lower than the limit values in Annex I.

2. In zones on its territory which the Member State concerned considers should be afforded special environmental protection, the Member State shall fix values which are generally lower than the guide values in Annex II.

3. Member States shall inform the Commission of the values, deadlines and timetables they have laid down for the zones referred to in paragraphs 1 and 2, and of any appropriate measures they have taken.

Article 5

In addition to the provisions referred to in Article 3(1) and Article 4(1), Member States shall, with the object of taking further precautions for the protection of health and the environment, endeavour to move towards the guide values in Annex II wherever the measured concentrations are higher than these values.

Article 6

Member States shall establish measuring stations designed to supply the data necessary for the application of this Directive, in particular in zones where the limit values referred to in Article 3(1) are likely to be approached or exceeded and in the zones referred to in Article 3(2); the stations must be located at sites where pollution is thought to be greatest and where the measured concentrations are representative of local conditions.

Article 7

1. Following the entry into force of this Directive, Member States shall inform the Commission, not later than 6 months after the end (31 March) of the annual reference period, of instances in which the limit values laid down in Annex I have been exceeded and of the concentrations recorded.

2. They shall also notify the Commission, not later than one year after the end of the annual reference period, of the reasons for such instances and of the measures they have take to avoid their recurrence.

3. In addition, Member States shall forward information to the Commission, at its request, on the concentrations of sulphur dioxide and suspended particulates in any zones they have designated pursuant to Article 4(1) and (2).

Article 8

The Commission shall each year publish a summary report on the application of this Directive.

Article 9

Application of the measures taken pursuant to this Directive must not bring about a significant deterioration in the quality of the air where the level of pollution by sulphur dioxide and suspended particulates at the time of implementation of this Directive is low in relation to the limit values set out in Annex I.

Article 10

1. For the purposes of applying this Directive, the Member States shall use either the reference methods of sampling and analysis referred to in Annex III or any other method of sampling and analysis in respect of which they demonstrate to the Commission at regular intervals:

- either that it ensures satisfactory correlation of results with those obtained using the reference method;
- or that measurements taken in parallel with the reference method at a series of representative stations chosen in accordance with the requirements laid down in Article 6 show that there is a reasonably stable relationship between the results obtained using that method and those obtained using the reference method.

2. Without prejudice to the provisions of this Directive, a Member State may also use, pending the decision of the Council on the proposals from the Commission referred to in paragraph 4, the sampling and analysis methods laid down in Annex IV and the values associated with these methods also laid down in Annex IV in substitution for the limit values set out in Annex I.

3. A Member State which decides to avail itself of the provisions of paragraph 2 must however take measurements in parallel at a series of representative measuring stations, chosen in accordance with the requirements of Article 6, in order to verify the corresponding stringency of the limit values set out in Annex IV and Annex I. The results of these parallel measurements, including in particular instances in which the limit values laid down in Annex I

have been exceeded and the concentrations recorded, shall be forwarded to the Commission at regular intervals and at least twice a year, for incorporation in the annual report provided for in Article 8.

4. The Commission shall, after five years, but within six years of the expiry of the time limit of twenty-four months specified in Annex 15(1), submit a report to the Council on the results of the parallel measurements carried out under paragraph 3 and shall, having regard in particular to these results and to the need to avoid discriminatory provisions, make proposals relating to paragraph 2 and Annex IV. In the report provided for in Article 8 the Commission will indicate whether it has noted instances in which the limit values fixed in Annex I have been exceeded to a significant extent on repeated occasions.

5. The Commission shall, in selected locations in the Member States and in co-operation with the latter, carry out studies on the sampling and analysis of sulphur dioxide, and of black smoke and suspended particulates. These studies shall be designed in particular to promote the harmonization of methods of sampling and analysis of these pollutants.

Article 11

1. Where Member States fix in border regions values for concentrations of sulphur dioxide and suspended particulates in the atmosphere in accordance with Article 4(1) and (2), they shall hold prior consultations. The Commission may attend such consultations.

2. Where the limit values given in Annex I or the values referred to in Article 4(1) and (2), inasmuch as the latter values have been the subject of consultations in accordance with paragraph 1, are or might be exceeded following significant pollution which originates or may have originated in another Member State, the Member States concerned shall hold consultations with a view to remedying the situation. The Commission may attend such consultations.

Article 12, 13 and 14 set up a committee for the technical adaption of the Directive.

Article 15

1. Member states shall bring into force the laws, regulations and administrative provisions necessary to comply with the Directive within twenty-four months of its notification* and shall forthwith inform the Commission thereof.

Member states shall communicate to the Commission the tests of the provisions of national law which they adopt in the field covered by this Directive.

Article 16

This Directive is addressed to the Member States.

Annex I	tabulates the limit values.
Annex II	tabulates the guide values.
Annex III	prescribes the sampling and analysis methods.
Annex IV	sets the limit values and methods that will be used by Germany and in part by Italy.
Annex V	reproduces the text of the draft ISO standard for SO_2 analysis.

* The Directive was notified on 15 July 1980

ANNEX B

STATEMENTS ACCOMPANYING THE DIRECTIVE

- Re Article 9

"The Council and the Commission state that Article 9 may not be interpreted as prohibiting the siting of new plants which are sources of SO_2 discharges and suspended particulates in zones in which the level of pollution, at the time of implementation of this Directive, is low in relation to the limits contained in Annex I to this Directive".

RE ANNEX I, TABLE A

APPLICATION OF THE LIMIT VALUES AS A PERCENTILE
(IN ANNEX I, TABLE A)

"The Commission states that in order to comply with the limit values defined as a percentile in Annex I, Table A, the Member States shall apply:

i. either the limit values for sulphur dioxide and the associated value for suspended particulate matter on a daily basis; such values must be complied with during at least 98% of the 24 hour measuring periods during the year.

ii. or the limit values for sulphur dioxide and the associated value for suspended particulate matter, both of these values to be defined as the 98 percentile of all the average daily values recorded during the year.

For the practical application of these provisions the 98 percentile of the average daily values of suspended particulate matter recorded during the preceding annual period will be used as the reference point for determining what measures should be taken to comply with the provisions of the Directive."

NATIONAL SOCIETY FOR CLEAN AIR

47th CLEAN AIR CONFERENCE
22 - 25 SEPTEMBER 1980
BOURNEMOUTH

POLLUTION AND THE COMMUNITY

by

Frank Haynes, M.P.

National Society for Clean Air
136 North Street
Brighton BN1 1RG
England

The community is made up of individuals and we should remember that any action that we take as a society should be an attempt to improve the lot of the individual. I have been a member of the National Union of Mineworkers for thirty-four years, a Local Authority member for sixteen years and a member of the Nottinghamshire County Council for fifteen years. I have been a Justice of the Peace for twelve years and Chairman of the Central Nottinghamshire Community Health Council for five years. It has been my privilege to serve on the National Council of this Society for six years and on the East Midlands Divisional Council for seven years. I have been a Member of Parliament for Ashfield for almost eighteen months. You can see that I have had the privilege over a period of many years of being in daily contact with different types of persons from all walks of life, people who when taken together form the community. I feel qualified therefore to give this paper on how the community views pollution, what it thinks of the way in which the problems are being tackled and how the method of approach could be improved.

Throughout these years my principal interest has been public health and it was because of this that I became a convert to smoke control. I quickly realised that it was not going to be an easy gospel to preach to the man in the street, particularly in the mining area in which I have lived and worked. Miners at one time thought that the steps proposed to get rid of pollution and give clean air would do them out of a job. Time has proved these fears to be groundless and few miners now oppose action to reduce pollution. I feel very pleased about this as I firmly believe that men who spend their working day in dark, dusty conditions should be the first to enjoy the benefits of clean air and sunlight when they return to the surface. I also feel strongly that the coal which has been so hard won by the miners should not be wasted by burning it inefficiently either in the home or by industry. Any improvement in efficient combustion must reduce the amount of fuel burned and also the smoke emitted.

It is now commonplace for people to ask if areas in which they live can be included in smoke control areas. This is often due to them visiting friends who live in smoke control

areas and being impressed by what they see; they are dissatisfied when they return to their own smokey streets. Many people would like to carry out the work necessary to make their house smokeless regardless of the fact that they are not likely to be included in a smoke control area for some years. When they are told that their houses will not be in an area for some time these people often ask if they can carry out the necessary work and claim the grant, only to be told that individual applications cannot be considered. The person concerned then does one of two things, he either gives up the idea of carrying out the conversion or he does the work entirely at his own expense. Either way he blames his Local Council for unnecessary bureaucracy. Over the years many Local Authorities have made approaches to the Department of the Environment and its predecessors, asking to be allowed to pay grants in such cases, but these applications have always been rejected. My own personal view is that individual applications should be dealt with in the same way as housing improvement grants. If this had been part of the procedure from the beginning, I am confident that by now the vast majority of houses would be smokeless and the job would have cost far less than it will in the future. We are caught in a vicious circle, the longer the work waits the more it will cost. This in turn results in fewer houses being converted out of the money available and the date when the task is to be completed has to be continually extended. There is now a temptation to choose areas where the largest number of houses can be included at the smallest cost, thus ignoring dense areas containing a smaller number of older houses which are major areas of pollution. Anything that delays the completion of the domestic smoke control programme is to be deplored, as whenever a smoke control area is made there is a noticeable reduction in pollution, particularly by smoke in that area. It is clear from the experience of those Local Authorities who have made good use of the smoke control area method of tackling the problem of ground level concentrations of smoke and sulphur dioxide, that this is the best approach, and one which makes the most of the money and labour available, although as I have said I think it could be speeded up by restricting the programme to areas. The improvement of air quality in urban areas is there for all to see and can be regarded as a major achievement. We must not,

however, become complacent and should remember that the Air Quality Standard to be introduced by the E.E.C. in 1983 and enforced by 1993 has not yet been met in many parts of the country. It is therefore likely that in certain areas the Government will have to exercise its powers under the Clean Air Act 1968 to force some Local Authorities to instigate or extend smoke control areas.

I sometimes feel that smoke control is too costly for some of our less well off inhabitants and I wonder if they could be helped financially by giving extra supplementary payments or the subsidising of solid smokeless fuel. I think that discretionary financial aid should be more readily available to the less well off in smoke control areas. I am thinking of the typical case of an elderly person who has an income which is just sufficient to make him ineligible for council discretionary assistance although the cost to him could be as high as several hundred pounds. What I am suggesting is that we should be more generous in our assistance to this type of person.

The National Coal Board deserve complimenting on their contribution to clean air both in the industrial and domestic fields. For the latter they produce solid smokeless fuels and will when requested supply these fuels to miners in lieu of coal for their concessionary allowances. They also provide an excellent advisory service for members of the general public; this is quite separate from the advisory service that is available to the industrial user of solid fuel. The National Coal Board have eliminated in the East Midlands at least, a serious nuisance which used to be commonplace. I am referring to the smoke and dust emitted from burning spoil tips. Not only has this nuisance been removed in the area that I have knowledge of but the Board spends considerable sums of money to reclaim spoil tips as soon as possible, thus removing a visual nuisance in addition to preventing pollution. It is not uncommon for reclaimed tips to provide cereal crops or support a head of cattle within months of the last spoil being tipped. Reclamation does not wait until all the tipping has been carried out and cattle or sheep can often be seen grazing at one end of a tip while spoil is still being tipped at the other.

I am sure that most of the legislation introduced concerning smoke and noise has been done as a result of the action taken by Local Authority members through their Associations and also due to the lobbying and pressure exerted by this Society. I have been rather concerned at the change of approach by the Society during the last few years. It seems to me that the "Ginger Group" type of paper that was commonly given to the Annual Conference has been replaced by learned papers, excellent in their own way, but not likely to forward the main aims of the Society to any great extent. They are highly technical and of a minimal interest to Local Authorities and do not allow the Local Authority Representatives to join in the discussion. I was, therefore, very pleased to read the programme for this Conference and to note that the subjects are more "down to earth". I am hoping that this signifies a change back to the days when we as a Society stood against any form of pollution and backed any action from whatever quarter, which was calculated to improve the conditions under which the community live.

In general, industry has made far more progress towards the reduction of pollution than Local Authorities. I am aware that this improvement is often due to economic considerations but nevertheless in the main, industry has put its house in order. The emission of quantities of smoke from industrial chimneys is now largely a thing of the past and it is unusual to see a factory chimney emitting dark smoke. As I have already said, this is largely due to industrialists being made aware of the fact that smoke is unburned fuel and that fuel is too costly to be wasted in this way. Whatever the reason, the problem of industrial smoke has to a great extent been solved, but it has been replaced by another one, industrial noise. It is likely that this nuisance has always been with us but more complaints are being received as the community becomes more critical of the intrusions into their lives and demand an ever higher standard, both with regard to smoke and noise emitted from industrial sources. The problem of noise is more difficult to deal with than that of smoke as any work of improvement is usually expensive and, unlike that taken against smoke, does not show any tangible returns. However, in the main, industry faces up to its responsibilities and most factory owners do their best to

prevent noise from affecting the general public and their employees. They now have a legal obligation to protect the latter from the effect of noise and this is not before time, as I am convinced that many people who suffer from impaired hearing do so because they were not protected against the effects of noise many years ago.

In the past as a Councillor and now as an M.P., I have had many complaints and enquiries made at surgeries and by letter regarding pollution. Problems which have been brought to my notice include:-

Bonfires

These can cause a lot of distress and aggravation. Although the Nuisance Law is available its use is thwart with difficulties, not the least of which is the difficulty encountered by Local Authorities in collecting adequate evidence. I think that this problem might be to some extent solved by the provision of Byelaws, restricting or even forbidding bonfires in certain situations.

Smoke Nuisance from Domestic Chimneys

Chimneys of dwellings are specifically exempted from the statutory procedure of Section 16 of the Clean Air Act 1956. Low or badly sited chimneys, especially of bungalows, often cause problems to neighbouring properties. I think that the only solution to this is for specific planning legislation to be provided to prevent this happening in the future, or possibly by the provision of Byelaws requiring smokeless fuels to be used where bungalows are intermixed with houses.

Noise

The Control of Pollution Act 1974 gave Local Authorities more powers to control the major sources of noise, such as factories, mines and construction sites. However, many minor but intrusive sources are inadequately dealt with or raise considerable difficulty. Noise resulting from the use of domestic property can include regular late parties and the repairing of cars or motor cycles. A common and widespread

problem is the excessive use of high powered audio systems or musical instruments in terraced or semi-detached property. Planning controls are inadequate where no business use exists and Local Authorities find it difficult to prove nuisance, as it is not easy for an Officer to be there at the time the nuisance occurs. Easier recourse to law for aggrieved occupiers would be welcome. The Society might usefully examine these types of social problems.

A programme of public education via the media, pointing out the problems and advocating a "good neighbour" policy may be worth considering. In fact it seems to me that there is surprisingly little propaganda on television and radio about either clean air or noise.

Places of Entertainment

Regular complaints are received of disturbance by noise from licensed premises. A possible and useful change in the law would be for magistrates not to issue extensions to licences after 11 p.m., unless the Local Authority gives a certificate showing that to do so would be reasonable in the particular situation. This would encourage greater control by Licencees over the noise emission and the behaviour of their clientele, with respect to neighbouring properties.

Motor Vehicles

Many motor vehicles are excessively noisy, particularly some motor cycles, and nothing is apparently done to enforce even the feeble standards that do exist. Perhaps the proper time to check noise emission for all vehicles would be when the vehicle is presented for its annual Ministry of Transport test.

Domestic Animals

I receive many complaints of disturbance by noise from dogs barking, especially when they are left alone for long periods or kept in kennels outside the house. I receive from time to time complaints of cockerels crowing, often from the very early hours of the morning. These are very difficult prob-

lems to deal with, but if a Byelaw could be introduced which requires cockerels to be kept at not less than say 100 yards from a dwelling, this would go a long way to removing that particular nuisance, as it would prevent cockerels from being kept in most urban areas. The problem of nuisance caused by domestic animals in general is a most difficult one and one in which legal action can only be taken after considering individual situations. Problems caused by noise and smells from modern farms are increasing as new houses are built on land adjoining the farm buildings. Such problems I have found give rise to a bad relationship between the farmer and the householders and they are generally insoluble.

Ice-cream Vendors

The practice of retailing ice-cream from vehicles equipped with chimes is widespread and although rather seasonal, it is not unusual for a street to be visited three times or more during an afternoon. Many of these retailers feel it necessary to operate the chimes during each movement of the vehicle and during the whole time of the movement, usually at high volume and often when the vehicle is stationary. I wonder if a degree of control on the time of each operation and the level of volume is feasible.

Sales of Coal in Smoke Control Areas

I regularly receive complaints of coal being sold to persons living in smoke control areas and burned on appliances in their houses. Most of these complaints refer to the sale of small bags of coal from retail shops. I am told that nothing can be done to stop this practice, as the retailer is not breaking the law although the purchaser probably is. In the case of a coal merchant selling coal in a smoke control area, both he and the purchaser are liable to prosecution but the fines are too small to be a deterrent to the unscrupulous merchant. The coal merchants themselves would like to see more legislation carrying penalties of sufficient severity to deter the few bad eggs, without being oppressive to the reputable dealer.

Control of Development of Industrial Sites

It is not enough to prevent problems arising between the occupiers of the site and adjacent dwellings. The Planners must ensure that processes carried out on the sites are compatible. In the area that I represent as an M.P., there is a chemical incineration plant which has been allowed to develop immediately adjacent to other industrial sites and in close proximity to dwelling houses. The odours from this plant make work on these adjacent sites most unpleasant at times and they do give rise to complaints of nuisance from the occupiers of the nearby houses. This plant meets the standards of the Alkali Inspectorate but still causes nuisance to nearby inhabitants. We are therefore faced with the situation of a properly run plant being wrongly sited. This is not the only type of plant whose processes give rise to emissions to the atmosphere. I feel that there should be an onus on factory management to notify the District Authority of the content of these emissions, where possible at the planning application stage.

Whilst on the subject of industrial sites, I think that it is about time that the government experts gave District Councils clear guidance on the effects on human beings of heavy metals e.g. lead. This guidance should, I feel, include the steps to be taken to confirm the existence of problems and also suggest what should be done to put any situation right, bearing in mind the cost benefit.

Conclusion

It must be remembered that ultimately it is the District Councils who are responsible for public health and that includes the protection of the community against the effects of smoke, dust, fumes and noise. The general public, as they become aware of the benefits obtained from the removal of these nuisances, are demanding increasingly high standards and they expect Local Authorities to heed these demands. Any assistance that the Clean Air Society can give, at what may be described as grass roots level, will be appreciated by the District Councils and ultimately by the community.

NATIONAL SOCIETY FOR CLEAN AIR

47TH ANNUAL CONFERENCE
22-25 SEPTEMBER 1980
BOURNEMOUTH

ENERGY, NOISE, ROAD VEHICLES AND SMOKE CONTROL

PART II
DISCUSSIONS

136 NORTH STREET
BRIGHTON BN1 1RG, ENGLAND

47TH ANNUAL CLEAN AIR CONFERENCE,
BOURNEMOUTH, 22–25 September 1980
PART II – REPORT OF DISCUSSIONS

CONTENTS

ENERGY FOR THE 1980s: PROSPECTS FOR CLEAN AIR

KEYNOTE ADDRESS BY SIR JOHN GREENBOROUGH, KBE

Upon receiving this invitation I immediately looked back on what I had said in my two Presidential Keynote addresses to see whether conditions and prospects today will not enable me to use them again and save a lot of work - and of course test the memories of the audience who were then present.

This temptation came to me in part by hearing of a young undergraduate who had failed his economics examination at first attempt. When he sat it again the following year he was astonished to be confronted with questions identical to those he had received the year before. Being a young man of impeccable honesty he called his professor to point this out. Oh yes, replied the professor, the questions are in fact the same but you see the answers this year will be different.

In my 1974 Presidential address I spent some time talking about world economic growth. And I mentioned on that occasion that in the space of 4 short years since the year of 1970, our expectations for world growth had moderated considerably. From the heady days of 1970 when continuing world growth was thought to pose a problem for pollution and the environment, by 1974 our main concern was whether world economic growth was in any way attainable at all for several years. Six years later, I think it unlikely that I can be much more optimistic about the future prospects for significant growth of the world economy in the immediate future. And certainly not while oil prices continue to rise and some OECD countries are unable to keep inflation better under control.

Of course much has happened in those 6 intervening years, much of it to the detriment of world growth overall. Oil prices have risen at a phenomenal rate. In fact they have again soared since the Iranian disruption at the end of 1978. And as a result of this, some OPEC countries have accumulated large trade surpluses - estimated at more than one hundred

billion dollars in 1980 alone. This implies balance of trade deficits in the rest of the world, which, while they continue, place severe constraints on the future growth of world trade and output. Hence the vital importance for the benefit of us all, developed and under-developed countries alike, that OPEC countries come to a sounder agreement over future pricing of oil and over increasing their aid to the third world.

Accompanying what Chancellor Schmidt recently termed the "oil price explosion" has been the inability of the industrial nations to reduce and stabilise inflation. In the UK it is a problem with which we are all too familiar, and which cannot all be laid at the door of oil price rises. None the less, the fact that the inflation rate in the OECD area as a whole has remained volatile in the last few years and is only now beginning to show some downturn, will all have a considerable effect on our expectations for world growth in the next few years.

But though our expectations may have changed considerably over the last 10 years and we have had to adjust to the fact that the onward march of world growth is not inexorable, I do not think we want to turn ourselves into latter-day Wordsworths. Far from it. I believe the demand for improved living standards, in particular the demand for a better quality of life is as strong, if not stronger, than ever. Certainly in the Western World there is no indication that we are prepared to tone down our aspirations as individuals or as a society in terms of standards of living. Nor can we turn a blind eye to the plight of the under-developed world. Oil prices have had a considerable impact here. And it is just not on that, while OPEC countries sit on vast and accumulating surpluses from their production of oil, other developing countries are screwed into the ground with the threat of famine hanging over their heads in order to meet their oil bills. Something has to give. And it is therefore vital that we keep up the dialogue between North and South, between oil producers and consumers, to reach a satisfactory balance.

If we can get this right, then I am not gloomy that we can

once again anticipate reasonable levels of world growth, which will in turn affect the growth of the UK economy in the future. We all know that in the last couple of years forecasts for growth in the UK economy have been revised down on a number of occasions. Today the Treasury anticipate a fall of $2\frac{1}{2}\%$ in GDP this year, continuing into next, with a much bigger percentage fall in manufacturing. But, on the other hand, the signs are that we may be beginning to turn the corner. Recent falls in the Retail Price Index and in wholesale prices are all encouraging signs.

But what, you may well ask, is the significance of the world economy and of the UK economy to the prospect for clean air in the future? The answer is a simple one. Future prospects for growth in world trade and output are heavily dependent on world energy resources, for which there is an ever-increasing demand. Our ability to cope with that demand which has increased more than 3 times over the last 30 years depends in turn on our ability to conserve current energy resources and to put maximum effort into the development of new sources of energy. And both of these factors have a significant, if not conflicting, effect on the prospects for clean air in the future.

Let me just diverge for a moment or two to talk about prospects for world energy and the UK's part in all this. As is well-known, the UK will be self-sufficient in energy until at least 1990, if not until the end of the century. This has been brought about by the large reserves of oil and gas found in the North Sea and other parts of the Continental Shelf, and by longer-established coal production, and hydro-electric and nuclear programmes. UK oil production is currently running at about 1.6 to 1.7 million barrels per day, putting us in the same league with the top 12 producing countries in the world.

With such resources it might be thought that there is no need in the UK for energy conservation or for researching new sources of energy. But this is far from the truth.

Oil is an international commodity, traded and transported all over the world. Whatever we may think of the UK's self-

sufficiency, what happens on the world scene has a vital effect on us. Even if we may in future crises be somewhat insulated from shortages, we will not be insulated from world prices, nor from the economic repercussions of such shortages.

I spoke earlier of the increase in demand for world energy in the last 30 years. Nearly all of that additional demand has been met by oil and gas. But because of its easy transportability oil has become the balancing source of energy and now accounts for 55% of total energy consumption. What happens in oil, as we have found all too frequently in recent years, has a profound effect on world events.

The total oil production in the world currently amounts to just over 50 million barrels per day - a level which has been more or less the same for the last 2 to 3 years. Although it would be technically feasible to increase this level in the next few years, mainly from known reserves, this seems increasingly unlikely to happen. The rate of production in many countries is now governed not so much by technical factors as by other factors. For example, Kuwait earlier this year cut production, having adequate oil revenues and financial reserves to support its relatively small population at one of the highest standards of living in the world. Production in Norway, which already exceeds that country's needs, is deliberately being developed in line with economic policies rather than maximum output.

Political discontinuity is particularly noticeable at this moment with the war between Iran and Iraq. So several of the producing countries for entirely logical, political and economic reasons are restricting production to less than technically feasible levels, hence exercising conservation of energy resources.

For these reasons, it is becoming increasingly evident that the maximum level of oil production may have already been reached and whatever new reserves are found, output may never significantly exceed its present rate. This therefore puts increasing emphasis on the need to develop alternative sources of energy such as coal, nuclear, hydro and so on.

But because of the lead time for development of these sources in significant quantities - a minimum of at least 10 to 15 years - it also puts considerable emphasis on the need for energy efficiency.

The world economy will have to find ways of growing without consuming substantially more energy. In as much as new activities will demand some form of energy, this will have to be found by reducing the energy demands of existing ones. In addition, in as much as the growth of developing countries will increase their energy consumption, this may have to be found by moderating the demands of developed countries. Energy conservation is therefore not just something which is desirable, but is an essential requisite for economic growth and harmony.

One thing is certain - that energy efficiency of itself can do much to preserve and improve the environment. Noise, pollution and smoke all result from the inefficient use of energy. Considerable improvements in smoke emission are a direct result of more efficient solid fuel burning devices, just as more energy efficient road vehicles will reduce the quantity of exhaust components released into the atmosphere.

However, energy efficiency is not quite as simple as that. Although the price of oil roughly quadrupled in price between 1973 and 1974, it took all of us time to realise that a permanent change in affairs had taken place and that energy would not ever again be as cheap as it had been in the post-war years. After all, we had lived on a wave of energy euphoria. The price of oil fell sharply in real terms between 1950 and 1973 and we had come to rely on the availability of cheaper and cheaper energy as the main driving force for economic growth.

Following the sudden change, it was obvious that it would take a further period for articles to be redesigned for lower energy consumption and a further period again to bring them on to the market. This means that only this year can we begin to buy motor vehicles designed from the outset for lower fuel consumption, and many other improved products have yet to appear.

As far as the NSCA is concerned this means that from now onwards we should see increased progress in the pursuit of cleaner air. On the other hand there is still some headway to be made in encouraging people to invest in more energy-efficient devices and to understand the need for it. In spite of the considerable campaign mounted by the Government and others, many companies and individuals still do not recognise the possibilities, and how to achieve them. Even those who do understand this, need to be persuaded that the often considerable investment required will pay dividends. The difficulty is that the dividends are often rather far in the middle distance. Therefore it is vital to keep up the pressure on the general public to understand the need for energy efficiency.

However, more of a dilemma in terms of the environment may be posed by the development of new sources of energy. As you will hear from the excellent papers which will be presented tomorrow, all new investments in the field of energy (and elsewhere) are undertaken with a careful eye to the environment and its pollution in terms of safety, cleanliness and noise. Present standards are scrupulously maintained in as far as is possible. The question must now be, have we gone far enough? Has the battle for cleaner air under which we must also include safer and quieter air, been won? Are we in fact in grave danger if we go any further, of sacrificing our economic growth and standards of living on the environmentalists altar? Of course, there will always be room for improvement. Equally, there will always be those who oppose, for example, the development of nuclear power per se, from the comfortable world of adequate energy resources, with no regard for the future. My feeling is that if you were to offer them the alternative of continuing growth supported by nuclear energy to sustain and improve living standards on the one hand, and declining growth and depressed living standards on the other, then the anti-nuclear lobby might be very different, and be willing to reassess its stance.

I think we have to maintain a sensible balance, very much on the lines we have already achieved. We must be vigilant that those standards do not slip. On the other hand, we

need to be very aware that too high standards may jeopardise our whole future. Obviously in the next 10 to 15 years while alternative energy sources to oil are explored, the battle for clean, safe and quieter air must still go on. But we need to get our priorities right. The preservation of the environment is an essential part of the better quality of life we all desire. But so is economic growth and that cannot be sustained without adequate supplies of energy.

Demands for protection of the environment, and in particular, new proposals for EEC legislation on the environment are causing increasing pressures on the operating efficiency of British trade and industry. The need for sensible environmental control is acknowledged but business in the UK is concerned that some regulations are having significant and unforeseen effects, resulting in increased industrial and commercial operating costs. In some circumstances it is felt that environmental controls which have not been fully thought through can inhibit international trade and can even prevent proposed industrial development taking place, or result in existing industrial activity being closed down with adverse effects on the local or national economy.

This is really what I mean by the need for a sensible balance. To this end the CBI recently drew up a statement on the environment in which it urged trade and industry to continue to minimise any adverse environmental effect of its activities through the appropriate location and design of industrial projects and allied services; in which it urged business to continue to consult with those responsible for drawing up environmental policies and legislation to ensure that they understand their potential impact on industrial and commercial developments, and in which the CBI also made the suggestion that business should take account of the views and interests of responsible conservation and environmental groups when planning or carrying out industrial activies and should also review periodically its environmental policies and practices.

On the other hand the same statement commended to the Government that they did all in their power to continue the traditional UK approach to the protection of the environment

by the unique combination of voluntary and legislative processes and urged them to ensure that environmental constraints are based on good scientific knowledge and practice and do not needlessly inhibit future industrial and commercial development.

Whenever we consider the question of the environment, we need to bear in mind that trade and industry is the principal provider for goods and services, and the principal creator of the nation's wealth. Industry and trade must remain competitive. As the main source of technology, expertise and innovation, it has an important role in enhancing the well-being of society and in improving the man-made environment. Protection of the environment by industry, particularly pollution abatement, is an integral part of production and should be managed and costed as such. My point is this: industry is an integral part of society and accepts its responsibility to work in harmony with that society. On the other hand the imposition of unnecessary environmental constraints is irresponsible and a waste of scarce and valuable resources.

As I said, it is all a question of balance. Undoubtedly this organisation still has an important role to play in pursuing its objective of cleaner air and maintaining present standards. I believe that the job of this Society may also be to keep the sort of balance that I have discussed. And that must always be borne in mind as we look into what is, from many points of view, an uncertain and challenging future in terms both of the world economy and of world energy supplies. I think this conference over the next couple of days will do much to sustain common sense, in accordance with the high standards this Society has already done so much to promote since its foundation.

I wish the Conference every success.

SESSION 2

ENERGY AND THE FUTURE ENVIRONMENT

GAS AND THE FUTURE ENVIRONMENT
Mr. W. R. Probert, Director of Sales,
British Gas Corporation

OIL AND THE FUTURE ENVIRONMENT
Mr. P. B. Baxendell, CBE, Chairman,
Shell Transport and Trading Ltd.

COAL AND THE FUTURE ENVIRONMENT
Sir Derek Ezra, MBE, Chairman, National Coal Board

ELECTRICITY AND THE FUTURE ENVIRONMENT
Mr. G. A. W. Blackman, Board Member,
Central Electricity Generating Board

NUCLEAR POWER AND THE ENVIRONMENT
Dr. Lewis Roberts, Director of Harwell,
United Kingdom Atomic Energy Authority

DISCUSSION ON 'GAS AND THE FUTURE ENVIRONMENT' AFTER PRESENTATION OF HIS PAPER BY MR. W. R. PROBERT

A delegate asked whether the production of substitute natural gas would be anything like the old Lurgi process. MR. PROBERT said that the likely process of producing SNG stemmed from the old Lurgi process but the end product was quite different, and would be compatible with natural gas; however, the techniques had grown up originally from the old Lurgi gasifying process. Another delegate referred to a serious instance of pollution in his area, which had only been solved by the Lurgi process being overtaken by the arrival of natural gas. Mr. Probert said that the questioner would therefore presumably have been pleased to hear what he had said that morning about the extent to which the British Gas Corporation intended to produce and supply natural gas. He did not say that there were not environmental implications of SNG - the plants would be large, not situated in every small town as had been the case of course in the old carbonising days, and great care would have to be taken to ensure minimal environmental impact, but he did not see any major

problem at that stage in being able to meet the necessary environmental requirements.

MS. P. GRIFFITHS (Department of the Environment) asked Mr. Probert how long the process of Environmental Impact Analysis, which he had mentioned in his paper, took the Gas Corporation in the planning of a project. MR. PROBERT replied that the Environmental Impact Analysis might take up some six to nine months in a total planning period of about two years, and added that spending more time at the beginning would often ease the progress of a project later.

A delegate asked whether the British Gas Corporation had completely ruled out supplementing natural gas reserves by importing LNG. Mr. Probert replied that they had not. It was quite true that the international gas market would progressively be LNG-based. That was the only real way in which gas could be trans-shipped. The U.K. was fortunate in that gas could be brought ashore either from UK offshore fields, or imported by pipeline, which avoided the need for LNG. But current developments on the international supply scene could be significant. Sir John Greenborough had talked the previous evening about OPEC oil developments. There were parallel gas developments through OPEC, with the price of LNG being raised and becoming increasingly oil-related. Sumatrack in Algeria had recently terminated supplies to France and to El Paso in the USA and had been demanding prices per million Btu's which equated basically to delivered price of oil. In the end, they had been unsuccessful in achieving that; some compromise deal had been worked out, but it was impossible to predict how long it would last. However, as a result of that deal there had been a significant increase in LNG prices, and Mr. Probert was certain that the OPEC suppliers would maintain that sort of drive. The net result had already been seen in Holland, which imported, or was attempting to import LNG; they had been stopped temporarily, and were desperately trying to raise their prices across frontiers to reflect not only their own reserves' depletion strategy but the higher cost of the LNG they would have to buy. LNG was not therefore an attractive option if there was anything else available; the U.K. was fortunate in having something else at that stage.

LNG could not be ruled out, but it was unlikely to figure prominently as a component in the British Gas Corporation's supply profile for many, many years.

DISCUSSION ON 'OIL AND THE FUTURE ENVIRONMENT' AFTER PRESENTATION OF HIS PAPER BY MR. P. B. BAXENDELL, CBE

PROFESSOR R. S. SCORER (Imperial College) said that he had very much welcomed Mr. Baxendell's talk. He said that price rises had been very jerky but many people had seen them as inevitable anyway; it was the jerkiness that had upset people and he asked Mr. Baxendell how far he thought price rises could go. He wanted to know what the actual value of oil was, what it was worth, not what was the least it could be sold for. A dollar or two a barrel had been an absolute giveaway price and economic growth on that basis had been something that any fool could have had. The current concern was with what the best technology could produce in the way of value from a barrel of oil: was it $200 worth? If it was, by present-day technology there were a lot of jerks ahead; if it was only worth $50, then obviously the price could not go beyond that.

MR. P. B. BAXENDELL, replying, agreed that the abruptness of the price rises was a very dangerous phenomena, and the magnitude of the "jerkiness", as Professor Scorer had aptly described it, was well illustrated on the graph shown earlier. The effect of those dramatic rises was extremely serious to world economies and, incidentally, in its working effect to the distributing companies.

He believed that OPEC appreciated that major price rises placed a great stress on consuming country economies; delegates would probably have read recently that OPEC was attempting to derive a formula which would remove some of the erratic nature of price progression. They appeared to favour a system which would see OPEC's marker crude pegged on a formula that would relate to currency fluctuations, to some degree to inflation and to the growth rate in the OECD countries. However, no decision on such a formula had been reached at the recent Vienna meeting.

There were certain difficulties, however, in the application of such a formula as it essentially represented a floor price; that implied that under accident-free conditions the price would rise steadily, eliminating the "jerkiness". A problem would arise if another political accident were to disrupt supply and an acute shortage develop. The price could well then outstrip the formula under demand pressure and another sudden major price rise could occur.

He fully shared Professor Scorer's concern with that problem and its seriousness but he could not see a satisfactory solution. He wished he could. As he had said earlier, the price rises presented major problems to the companies in the form of major working capital increases. For instance the price rises that had taken place over the previous two years had added two and a half thousand million pounds to the Royal Dutch/Shell Group's working capital requirements due to stock valuations, a very difficult situation to sustain commercially.

On just how high the oil price could go, he said that one concept was to view the limit as the alternative energy cost, but that again was a difficult concept as there were not sufficient quantities of alternative fuels available in the short to medium term to replace oil. He presumed that the real ceiling was the level that customers were prepared to pay without reaching a turnover point where economic collapse occurred. Putting it another way, it was the economic health of the customer, from OPEC's point of view, that represented the real ceiling.

That lead on to a consideration of the problem of the non-oil producing third world countries. The dramatic oil price rises had hit the economies of the LDCs very hard indeed. The increase in their oil import bill had been dramatic. Many of them were already very heavily in debt and the problem of further outgoings on their current account was already an almost impossible burden. OPEC was well aware of that problem but little progress in its solution had so far been made. It believed that the problem of energy supply and the LDCs would have enormous repercussions on world relationships.

MR. WESTERMAN (Nottingham City Council) said that delegates had heard a great deal about the political, sociological and economic aspects during the previous hour or so. But, returning to pollution itself, he said that the oil companies carried a lot of influence and had a lot of concern, so the conference had heard. He asked what effect they were having on the shipping world in order to prevent or minimise such appalling incidents that there had been in previous months or years, such as the one that had affected the French beaches.

MR. BAXENDELL said first of all and very firmly that the major oil companies had achieved a great deal and continued to work hard in the area of marine pollution.

There were two principal aspects of such marine problems. First, there was the problem of deliberate tank cleaning at sea, and he believed he could say very confidently that that practice did not occur with vessels of major oil company fleets, nor in vessels under charter to major companies. There were rigid regulations and practices that the oil industry attempted to apply to make sure that that did not happen. It was a practice that oil companies did their utmost to prevent.

The second problem was much more difficult, the question of how disaster could be averted. The difficulty with marine disasters was that time after time, analysis of what had occurred revealed that it was not equipment failure but human failure that had been the cause of the problem. Human failure was a very difficult thing to guard against. There was the most elaborate training within company fleets; there were simulators and extensive training courses and he believed that an extremely high standard was set. Nevertheless, occasionally accidents did occur and all he could say was that within their own areas of influence oil companies did their utmost to try and make sure that every possible measure was taken to prevent them.

MR. F. REYNOLDS (Leeds City Council) said that until that point, Mr. Baxendell had been referring to the international situation and its potential effect on the energy situation in the UK; but he wanted the emphasis to be specifically on

the UK for a moment. He had understood that the North Sea energy production would shortly be approaching what could be regarded as self-sufficient for the UK. If that was so, he wondered to what extent the UK could be independent of OPEC and other countries' production in order to develop its own energy policy; he added that he was well aware that Government had not yet produced a fuel policy for the country.

Secondly, he said that Mr. Probert, for the Gas Industry, had that morning indicated that they were to direct supplies in the future to the premium areas; that was, to certain classes of industry and certainly to the domestic market. Mr. Reynolds felt that if the oil industry were to do the same, which had partly been hinted at, but not directly stated, i.e. that oil in the future ought to be directed to feedstock for the chemical industry and to transportation, that would have the effect of placing a pretty heavy load on the other fuels, particularly coal. He thought, from Mr. Baxendell's indicated acceptance of what he was saying, that there was to be a new trend in fuel making and utilisation in the UK.

MR. BAXENDELL said that he had intended to refer to the United Kingdom specifically that morning but time had got a little short. The United Kingdom certainly was in a very favoured position in energy terms. It had gas, it had abundant coal, it had oil.

However, the oil availability should not be overestimated. Self-sufficiency levels had been reached fairly rapidly but the problem with oil fields was that they declined with time in production rate. They were like any other form of reservoir under pressure in that they produced at a high rate initially and then, as the pressure dropped, so the rate of offtake declined. In fact, from the 25 fields that were under production or under development at that time, over self-sufficiency levels would be maintained until the late 80s, and then levels would begin to drop below self-sufficiency again from those sources. Maintaining self-sufficiency levels for longer periods was liable to be difficult, in that he believed that most of the major fields in the UK sector of the North Sea had been discovered

already and that further future developments were going to be concentrated in a multiplicity of smaller fields. That meant that an extremely high level of development activity would be necessary in order to maintain offtake levels. In his view it would take something like three times the current level of offshore activity to maintain oil self-sufficiency through the 90s. He believed that in totality an adequate reserve was there to maintain self-sufficiency into the mid-90s but that was probably as far as it could be stretched.

Another aspect of production capacity related to pricing. So far the United Kingdom had maintained a policy of maintaining international pricing parity for UK oil. In that area governments had a choice - they could adopt either a preferential price for domestic consumption (as had been the case in the US and Canada) or they could maintain a world pricing policy. There were arguments on both sides. On the one hand preferential pricing assisted industry, on the other hand, world pricing produced higher levels of taxation from the oil producing companies which could then go into the common government pot and be directed to whatever area government decided. The numerical benefit would remain approximately the same - it was a question of government policy on how to distribute the total. But with oil at world price, competitive situations arose with other domestically produced fuels.

The question had referred to gas being deliberately aimed at certain preferential markets. He believed that that would also be the case for oil. The use of oil as a heavy fuel, for example, ought to be discouraged. Refining processes - conversion processes - could convert fuel oil into lighter products which could be used in areas where there was as yet no substitute - no economic substitute - such as transportation fuels and petrochemical feedstocks.

The problem however also related to the question of how fast the users of heavy fuels could switch over to other fuels such as coal, thus freeing up the fuel oil for conversion. In some cases that was relatively easy, for example in the cement industry, but in other cases the transition was difficult and expensive and, whilst it made conservation

sense, it was a difficult thing to persuade the user to make the change in difficult economic times such as most industries were going through.

DISCUSSION ON 'COAL AND THE FUTURE ENVIRONMENT' AFTER PRESENTATION OF HIS PAPER BY MR. W. R. PROBERT

COUNCILLOR T. JONES (Manchester Area Council for Clean Air and Noise Control) said that it gave him great pleasure to listen to Sir Derek because he had worked for the previous 40 years as an underground miner. In 1972 Sir Derek had visited one of the faces at the Bickershaw Colliery, where Sir Derek had had the pleasure of meeting one of his old artillery friends who had served in the same troop as him during the war. Councillor Jones thought that the problem over the past years had been the lack of any positive national energy policy by whatever government had been in power. It had always been an *ad hoc* policy. The three nationalised industries advertised on television, and Councillor Jones felt that they ought not to be in competition; there ought to be one national energy policy.

The massive improvement in air quality in the Manchester Area Council for Clean Air had been hard won by sustained efforts over a long period. The major factor had been the reduction in the amount of fuel burnt. The improvements were not, however, once and for all, and conditions could deteriorate rapidly if the misuse of coal was permitted to return. The argument was not whether more coal should be used but where it should be used and about how it should be controlled so as to minimise the emission of smoke, grit and dust and to avoid the significant increase in sulphur dioxide in heavily populated areas. It had been the serious inefficiencies in the use of coal which had accounted for the most gross air pollution and which still accounted for about 80%. He asked Sir Derek whether the NCB could increase the outputs from the mines in the short time available to cope with the added requirement in industry, especially if the demand for coal were to be as great as was anticipated towards the end of the century. He also asked what technologies were being developed for new installations for

people in industry to buy, to change to solid fuel burning.

SIR DEREK EZRA, replying, said that Councillor Jones had asked two basic questions, first, whether there should be a national energy policy. Sir Derek had concluded his remarks by saying that he thought that there ought to be a longer term strategy for energy than he believed existed at that time. He thought that, because the energy scene was uncertain, there was all the more reason why there should be a clear policy to deal with it. He did not believe that because the situation was uncertain, matters should be left to sort themselves out. It was not an area where things could be left to sort themselves out; it was much too serious. If a major shortage arose, or the UK was dependent upon external sources of energy, possibly in the 1990s when the rest of the world would be hungry for energy, the country would be in a dire situation indeed. The UK had the enormous advantage of the North Sea and best use had to be made of that finite resource. It was also necessary to develop the country's other resources. More effective utilisation had to be encouraged, and there had to be some stimulus to industry which wanted to convert to coal, so that it had the means to do so. Therefore, he agreed with the view that there ought to be a more explicit energy strategy.

As to the National Coal Board's ability to meet the eventual demand for increased coal usage in industry, he said that they would certainly be able to meet that demand. The coal industry was building up capacity in order to be able to meet it. The right sorts of coal would be produced and, at the same time, the right sorts of appliances would be available for that coal to be used with maximum regard to the environment. He was absolutely confident of that, so long as the momentum that had been established was maintained. The industry had to ride through the storm of the current recession. If either the NCB or the manufacturers of equipment were to be put off by the recession, then the answer to that question would be in the negative: there would be neither the resources nor the technology. The challenge, the immediate challenge was for the industry to keep going.

MR. MALDWYN JONES (Cynon Valley Borough Council) said that his Authority was a coal mining community and the home of Dantes Inferno, Mark II, sometimes referred to as National Smokeless Fuel's Phurnacite Plant in Abercwmboi, Aberdare, which surpassed anything the original had to offer in the form of pollution. That plant, as Sir Derek was no doubt aware, made solid smokeless fuel, one of the plants which Sir Derek had stated were giving some cause for concern. Mr. Jones said that the briquettes might be smokeless but the valley certainly was not. Everyone had heard of the USA volcanic eruptions and of the fields of dust which it had left behind. But it was not necessary to go to the States to see such devastation; all people had to do was go to Cynon Valley where that disticoke, or as he called it, dusty coke process, flatulated stinking gases and covered the valley in black filth. The Alkali Inspectorate had termed it the greatest single air pollution problem in the UK.

Back in 1978 Mr. Jones had been one of an investigating team which had looked into the causes of pollution at the plant; the team had realised that the disticoke process was simply environmentally unacceptable and that a new process had to be looked for immediately. National Smokeless Fuels had proved to be great escape artists and the plant would and should have been closed down years before but for the wonderful "ring of confidence" known as Best Practicable Means and a string of politicians and diplomats who had come in the form of Alkali Inspectors. Mr. Jones hoped that Mr. Tunnicliffe was present and would carry his observations back to his chief who, after all, was the responsible enforcement officer as it was a registered works. It was certainly a case of the tail wagging the dog. The Phurnacite plant produced at least 15% of the nation's solid smokeless fuel and a new process was the only way for survival all round. Mr. Jones asked Sir Derek whether he and his Board were prepared to wipe out the supply. Money was needed immediately for investment in a new process. The one suggested was Ancit, which the investigating team had been told was both environmentally and economically acceptable. However, both the government and the NCB appeared to be blind to the needs of the Cynon Valley community for an acceptable environment and to the needs of

consumers in the UK for a constant and adequate supply of smokeless fuel, for which there was an abundance of raw materials. A figure of £36 million was required. That might seem a lot at that time; equally, so did Mr. Jones' own house mortgage, but he hoped that in a few years time, that would have proved worthwhile. He knew that investment for the plant had been turned down and urged Sir Derek and his Board to reconsider the decision and treat his comments as a plea, not simply a request. He said that Sir Derek's observations would be welcomed by the residents of Cynon Valley and the workforce at the plant.

SIR DEREK EZRA, replying, said that the point that Mr. Jones had raised was basic to the theme of the conference: how to reconcile energy requirements with environmental requirements. He himself had stated, and he was glad that he had, that there were some old plants which were taking the smoke out of solid fuel but which concentrated the pollution at the point of production. The Phurnacite plant, one which the NCB had inherited at nationalisation in 1947, was one such. It did concentrate a certain amount of pollution at the point of production. Unfortunately it produced a prime smokeless fuel and if the coal industry was deprived of that smokeless fuel, it would be very difficult to meet the requirements of the customers throughout the country. For some time the Board had been considering replacing the plant with a more modern type called the Ancit process, which had been developed in Germany. It produced an equivalent type of fuel with much less pollution and therefore would be environmentally much more acceptable but it unfortunately cost a lot of money. In no way, that the Board had worked out so far, could they charge a price for the product which would relate back to the amount of investment that would have to be put in to produce it. The costs of such plants, with inflation, were absolutely astronomical; the NCB had therefore gone to the Government and had put the problem to them, as a largely social problem - a two-part social problem; on the one hand, pollution at the point of production; on the other hand the desirability of the form of fuel produced which many households required.

They had asked the Government to make an exception to their

iron rule and see whether some financial assistance could be provided to enable the Board to undertake the change to the new process, because, otherwise, there was no way in which the Board could do it. The Government had considered the matter for some time and they had eventually decided that they could not provide assistance. The NCB were in the process of reconsidering the situation with the local authorities, with the unions, and with the consumer organisations to see what could be done. Sir Derek could not yet give an answer. If the environmental requirements were satisfied, the industry would be deprived of an essential form of energy, unemployment would be increased in the locality and, of course, there would be an adverse impact upon the supplying collieries who were providing the raw material. So there would be disadvantageous results. If the NCB were to invest the money themselves, they would be unable to comply with government strictures on their financial affairs. So the industry was caught in a bit of a trap and the Board had decided that it was necessary to rethink the whole matter. Sir Derek could not at this stage say how they could get out of that particular trap. The industry had not got the money; the fuel was needed and the community needed a better environment. Those were the three unpalatable ingredients which the Board faced. Sir Derek hoped some way out of the impasse would be found before long but he said that if anyone present could think of a way out, he would be delighted to hear about it.

MR. DAVID FISHLOCK (Financial Times) said that he was not quite certain why he had been asked to open the discussion on the session on Energy and the Future Environment except that of course he was a newspaper man, and from the media, and the media was some sort of mirror for public emotions. It was not always a perfectly plane mirror, perhaps, but he did not think the public would want that or that such a product would sell 14 million copies or so a day of London newspapers alone, and still more on Sundays.

He said that when the public read those crisp, snappy quotes from footballers or boxers or other entertainers who in reality were depressingly inarticulate, readers would realise that they were getting a little professional help from the

journalist. Similarly, scientists, engineers and businessmen - sometimes even the splendidly lucid and articulate gentlemen who had spoken that day, the Chairman included - needed the help of the media to explain their activities to a wider audience. However, he realised that it did not always come out the way that they had expected. Journalists prodded and poked away at weaknesses in their arguments, just as they prodded and poked at the arguments or the assertions of politicians.

Many of his colleagues who wrote about science and technology and its consequences in the national press seemed to regard him as an incurable technological optimist. Perhaps sometimes they had a point. He had once volunteered his own very small secluded village as a nuclear waste storage site, on the grounds that once all the waste was sealed up, the villagers would have no more trouble with property developers and others seeking to encroach on their privacy but he was a frank pessimist about many human activities. For example, he saw that the European Parliament was trying to legislate for the noise levels of lawn mowers. He could not help thinking that there were surely more important issues for those politicians to tackle while Western Europe slid into recession. He wondered whether next they would put on to their agendas the smoke levels of bonfires. He was also pessimistic about many of the so-called benign and renewable energy technologies and activities which his colleagues wrote about so enthusiastically.

Nuclear fusion, for example, had reached a stage of development where it needed all the help journalists could give to keep politicians from voting the research the huge sum of money it needed. He wondered whether there was a fusion technologist who would honestly claim that there would ever be either a cheap, a simple or a radioactively clean technology, much less all three as his press colleagues had often presented it. Everyone said nice things about coal nowadays because, as Sir Derek Ezra had said that morning, nationally and internationally it was needed and probably in vastly greater amounts than the world coal industry was likely to be able to deliver. But someone the other day had asked Mr. Fishlock if he knew what was Poland's biggest

single export and had gone on to explain that it was sulphur to Russia, in the form of air pollution from the coal-fired power plant down the eastern border of Poland. Mr. Blackman had raised the matter of windmills and wave power.
Mr. Fishlock said that he was fairly pessimistic about winds and waves and frankly doubted whether they would ever provide appreciable amounts of energy, except possibly for communities too remote from the national grid to get any economic advantage out of big generators. Those who lent money occasionally to inventors told him that this was the time of year when they were inundated with ideas for wave power machines from returning holidaymakers who had been dabbling their toes thoughtfully at the edge of the sea. The Edwardians had been just as optimistic about waves. An engineer in 1904 had taken out a British patent which, after observing that coal and petroleum were costly ways of propelling a ship, had gone on to propose a self-propelling mechanism which harnessed wavepower. In the first five years of the century, there had been no fewer than forty-six British patents for perpetual motion. Then the patent examiners had become a bit more critical.

The media reflected - some might say embellished - a general public interest in controversy, in disharmony of view, in conflict. It did worry some newspapermen that so much news was presented as a conflict between parties, or as a conspiracy by those with the power to thwart the good intentions of those without it. The research chief of a British oil company had told him that there was a segment of society which firmly believed that a pill had been invented which, when dissolved in water, turned it into petrol. Such people believed that only the wilful determination of the international companies was preventing the public from learning this. Presumably the pill also produced petrol mercifully free from air pollutants, such as sulphur, which the oil industry failed to remove, and lead, which it added deliberately. Lead was a pretty good example of a pollution issue in which facts came a poor second to emotional response, as most newspapers would see it. The frustration felt by some people when medical science stubbornly refused to confirm some widely held belief about health and safety had become all too clear in March when the Government had published

Professor Lawther's report, "Lead and Health". To the immense annoyance of those who had convinced themselves that the use of lead in petrol ought to be banned outright because it was a major source of lead in air, the Lawther Report had drawn no such conclusions. It had found that airborne lead was not the most important contributor to total body burden of lead in the UK population; food and water contributed much more. But the situation had been, he regretted, custom-made for the media. Those who wanted to ban lead outright were articulate and passionate. Professor Lawther and his committee had been accused by some journalists of white-washing the problem and of producing the conclusion the Government had wanted, even of being in the pay of the oil companies.

In terms of news, and by that he meant the sort of news item that would hold the attention of millions of people, facts and reasons had little chance against the passionate and emotional appeal. For example, few MPs would stand up to Jack Ashley, even when his facts were completely wrong. Lord Ashby, the Cambridge and botanist and first Chairman of the Standing Royal Commission on the Environment, had made a very wry comment on the furore that had followed the Lead and Health Report. He had said, "When the public takes sides on a highly emotive issue, truth is the first casualty". Robin Day, in an interview in the Evening Standard the previous week had been remarkably frank about the weaknesses of that other branch of the media, television, in shaping public opinion: "For ten years now, I have been saying that television is a crude medium - a medium of shock and emotion rather than reason". He had gone on to give the example of John Anderson, the US presidential candidate, who was shown being pelted with eggs on a vivid TV news scene. Robin Day had pointed out that that item had said nothing at all about how Anderson's campaign had been going, or that the eggs had been thrown by a tiny dissident group. Robin Day called that "the distortion and trivialisation of facts". Television was a media which had an inherent tendency to distort.

Mr. Fishlock thought that the oil and electricity industry, and especially perhaps the nuclear industry, would know exactly what Robin Day had meant. Tiny dissident groups had

a tendency to hog the headlines with their activist views; an American electricity industry chief whom he had talked to the previous day had called it the tyranny of minorities. He had in mind, not those such as the Welsh delegates who had spoken so persuasively during the debate that morning about the air pollution involved in the production of smokeless fuel. Rather, he had been referring to those in the United States who wanted all US nuclear plants to be banned while, at the same time, wanting to hobble coal plants with pollution control measures of very dubious utility and simultaneously sought to block all price increases for electricity, regardless of the justice of the electricity company's case, and so prevent any further construction of large generating plant. Those who represented the vested interests in energy in the UK had given their side of the story. Mr. Fishlock asked any representative of a minority viewpoint, tyrannical or otherwise, who would care to open up the disscussion, to take the floor in their turn.

MR. I. W. BARKER (Director of Environmental Health, Sheffield) wanted to make a general observation and comment on the excellent proceedings that day. Conference had been treated to a comprehensive review of the world energy situation, its impact on global economies and its impact on international and domestic politics. The implications had been set out and had been done so by men who were pre-eminent in their respective fields; they had made their case and set out their views most impressively. But the message which he thought was coming across, very loud and clear, was one of moderation, moderation in reconciling the conflicting demands of environmental desirability and those of economic practicability. The message had been spelt out quite explicitly by Sir John Greenborough in his Keynote Address and the message had been implicit in the papers that had been presented so persuasively that day.

He felt that it was entirely proper for the representatives of the various polluting industries to promote views which were in the best interests of those industries and he applauded the reasoned and restrained arguments that had been presented that day. However, he did not believe it was equally proper for the National Society for Clean Air to be

unduly influenced by such views. The benefits which had accrued from the wholesale abolition of gross air pollution in the UK had been achieved, not by moderation, but by the crusading zeal of the Society backed by the total commitment of local authorities up and down the country in implementing the Clean Air Act of 1956. Had the Society been swayed by the persuasive arguments of moderation in the 50s and 60s, and the promotion of clean air had been left to the polluting industries reacting solely to market stimuli, he thought it was extremely unlikely that the pictures of England's traditional heritage which had been shown with such crystal clarity in Mr. Probert's outstanding presentation that morning would have been available to him.

His plea, indeed his exhortation to conference and to the National Society for Clean Air was not to be beguiled by the persuasive blandishments of moderation; that which was Caesar's should be rendered unto Caesar. Polluting industries, nationalised and private sector, had the resources and were well able to promote their own interests, as had been most impressively demonstrated that day. They had enough influence to counterbalance any environmental lobby and they were well able to look after themselves. But the National Society for Clean Air ought to promote its own role, of environmental protection and pollution control, with the same vigour which formerly typified its activities, and rediscover that crusading zeal which he feared was largely lacking at the time of speaking today.

SIR DEREK EZRA said that he would like to comment on Mr. Barker's remarks as he wore two hats, as President of the Society, which he was honoured to be, and also representing the National Coal Board. He agreed that the Society should maintain its role of fighting for what it had been set up to fight for. He thought, however, that it could fight for that more effectively if it did so from a position of knowledge and information about what was happening, particularly in the essential field of energy. The purpose of the energy session, in his view, had been for the Society's representatives to learn from those concerned in the energy field their view of the problem, so that as the Society pressed for what it believed to be

right, it could at least do so from the knowledge of what, to the producers of energy, appeared to be the facts of life.

PROFESSOR R. S. SCORER (Imperial College) felt it appropriate to thank the secretariat of the Society and the President, perhaps more particularly, for assembling such a high level collection of speakers, who could be prodded into saying something important. He wanted to go a little bit outside the usual brief and represent a fringe group or a minority, one with an historical interest as well as a technical and immediate one. He had recently spent a lot of time thinking about things on the historical scale, particularly over the past thousand years or so, and it was then obvious that in the early stages of the current present fossil fuel era, there had been a great deal of optimism. He could remember that in his youth the idea had been that science would take away all the burdens of life and make quite new freedoms possible. The position had altered, and was typified by an argument used very widely by Dr. Walter Marshall in his advocacy of more nuclear power. Professor Scorer had met Dr. Marshall on more than one occasion in debate on that topic, and found his arguments completely irrefutable, namely that nuclear energy was desperately needed. On the other hand, he thought that in saying that, Dr. Marshall was making an unconscious comment on the way civilization had evolved from one in which sources of energy were being developed, in the expectation that a better and freer civilization would be established, into one where mankind had been driven into a corner and desperately needed to develop nuclear energy because there was not enough of the other kinds to go round. That, of course, was all tied up with the population explosion, and the desirability of having a better way of life in the Third World, with the whole world becoming one economic unit. Also, the laws of economics had changed, now that there were global shortages of a fundamental nature, whereas only 20 years before the aim had been to develop resources and make them available to everybody as much as possible. If we had driven ourselves into that corner, we had to think very hard about what we were doing when we tried to get out of it, for we might inevitably drive ourselves in further. He had been to a

debate about 10 years before in which graphs had been shown of the prospective energy consumption and use in the year 2000, assuming the kind of growth that had been hoped for in the 60s. And, in the case of Japan, the forecast by the Institute of Fuel had been that Japan would probably be using 6 times as much energy per head by the year 2000 as in 1974. Exactly what they were going to do with that energy, and where they would get it from, had not been questioned. But the object of the forecast had been to provide a prediction of what was going to happen, in order to set about producing the energy required. It was, in 1980, realised that that energy simply could not be made available. If attempts were made to make that energy available in the way that had been predicted at that time, the situation in the year 2000 would be far more precarious than it was in 1980, for a much more highly consumptive way of life would have been developed for most people in the world; the population would have continued growing without the fear of not being able to be supported, and there would be far fewer resources available to deal with the situation.

At some stage, a halt had to be called for; in his opinion, one of the most difficult tasks that the leaders of the fuel industries had to face was to do their best to provide the energy expected while trying to put over the message to the public that there was going to be less available and that everyone must learn to use less. He was not sure how they could do that double task, but it had to be done and he had a sneaking feeling that, although his politics were utterly opposed to those of Mrs. Thatcher's government, the government had contrived - though not deliberately - to put people face to face with the problem. People could not have as much in the way of resources as they had been used to and it might be that that lesson was being learnt in a rather unexpected way. It might be that the historians of the future would see that the reaction, because of the current situation, had been not simply to reverse the policies or something of that sort, but that there had been a change in public attitude, and energy came to be regarded as something, not to be seized on and used up as much as possible but as something which was treasured and only used - if a person was the least bit conscientious - to the absolute minimum

necessary. He wondered who was noticing a change in public attitude. The media did not seem to want to encourage such a change; they were continuing to assume that if this and that were taken away, everybody would object and that meant fewer votes, etc. Professor Scorer believed that the public was being educated and would have quite different expectations, in 10 years time, from what it had in 1980.

SIR DEREK EZRA said that he did not believe the world was short of potential energy. It was there, but at that time there was a process of adjustment worldwide. Certain forms of convenient energy were getting short. Others were available. Decisions had to be made to adjust. That was what he considered to be the most important energy factor people were facing.

MR. NELSON agreed with everything that had been said. One question asked was how to tell the public that they might not get as much of a certain fuel, or all fuels in total, as they had been used to, or assumed they had a right to. For many varied reasons the Gas Industry had regrettably had to do just that the previous year. He was sure that delegates (from local authorities) would be aware that supplies had been limited to those who had a statutory right of supply. People could not take new loads over 25,000 therms per annum and only those within 25 yds of a main were entitled to a supply. That of course had been a short-term situation brought about by the flight from oil and the limit on the distribution system. The gas was available but there was a limit to how quickly more gas could be put into the system on a national basis. Mr. Baxendell assured the audience that it hurt to have to tell people that they could not have what they wanted, as much as it hurt from the customer's point of view. British Gas were carrying out a massive investment programme recently announced of £4,000 million to get over that problem, and bring forward the rate at which North Sea supplies could be made available.

DR. ROBERTS had a great deal of sympathy with much that Professor Scorer had said; it had been very well worth saying and was a lesson to be kept in mind. There had been only one analogy or twist of phrase with which he disagreed.

Professor Scorer warned that we were being cornered - getting into a situation from which nothing but desperate action might remedy - the usual reaction to feeling cornered. He thought that was the very danger that was apparent to those in the energy industries and which had been underlying much of which had been said that day, particularly from the point of view of the energy supplies of the world, not just Western Europe's energy supply. We were in a state of transition and, given the complexity of social adjustments as well as technological investment etc. that was required, a long time-scale was needed to adjust to it. He thought that nothing more important had emerged from the remarks of the various speakers than the need for a continuing and sensible plan towards a regime of energy use which would most definitely have to be more efficient and of energy supply which would also have to be more diverse than that which we had been used to in the last 20 or 30 years.

MR. M. O'BRIEN (Watford Borough Council) said that everyone knew that the price of gas had been put up to dissuade people from using it. He asked Mr. Nelson whether there was any possibility that the excess profit that the gas industry was accumulating could be ploughed back into the environment, to provide, perhaps, for insulation grants. If there was any excess profit, because of the increasing price, he thought that that should be done, as it would have an on-going effect of actually reducing consumption in the future. Sir Derek Ezra had indicated, in his reply to Mr. M. Jones from Cynon Valley, Wales, that the solid fuel industry really could not afford to provide a plant to produce Phurnacite which would not pollute the atmosphere. He asked whether it was fair that people living in Wales, Chesterfield, Bolsover and such places, where smokeless fuel was produced, had to suffer excess pollution so that the users of that fuel could get it at perhaps 10p or 20p per cwt cheaper.

MR. NELSON, on the question of price of gas being put up to persuade people not to use it, said that the industry sometimes needed the help of the media to ensure that the real message did get across. Personally, he would not agree that the price had been put up to stop people using it. Rather

than considering only what had happened over the past 18 months, it was necessary to take a longer term view. It had, he thought, been mentioned already that the price of fuel in real terms had gone down over a long period. For three years, from about 1976 through to 1979, the gas industry had gone through a period of enforced stability. The price of gas had been literally frozen over that particular time and the moves over the previous 18 months had redressed that situation to a certain extent. He imagined the point at issue had emanated from statements that the price of gas had had to go up to redress the imbalance between gas and other fuels. That was a political question. In his opinion, the price of gas ought to have gone up anyway.

On the second point of excess profits, he thought that it was debatable as to what excess profits actually were. Mr. Probert had talked that morning in terms of a £9 thousand million investment in the transmission system. That was a national asset, an asset which benefited everyone and equalled an investment of about £600 per consumer. In relation to the level of profits declared for the previous year, the percentage on that £9,000 million was very small indeed, not the sort of profit level that, in an expanding and thriving industry, could be expected to enable that industry to carry on. The gas industry was talking about investing for the future, about seeking new fields and assurance of supplies which every year cost more and more money in terms of improving the system, further exploration work, etc. In that situation those sort of profits were needed to stay in business and to ensure that supplies could be guaranteed for the future. There was another aspect also, the fact that the gas industry had been a net lender of money to the government during the previous year. There had also been talk of a gas level levy, but he could not get involved in the political side of that. The gas industry wanted to lend its current surplus to the government so that the money could be called in again when it was needed to carry out the investments that the industry felt were necessary for the future. Once that money had gone into the government pot it was very difficult for the gas industry to control what the government actually did with it. In many respects, it was a reduction of the public sector borrowing

requirement and therefore was assisting the public sector purse. The industry did a great deal, both internally and promotionally, on the question of energy conservation and for example had recently introduced new packs, called "Thermsavers", directly available from showrooms in certain areas. Using the profits specifically for that purpose did not come into it. The industry had been using current revenue budget in support of energy conservation for many years and the sort of excess profits that had been mentioned did not change that particular policy.

SIR DEREK EZRA said that he would briefly answer once again on the Phurnacite question. It was one of those dilemmas which were very relevant to the discussions that day. First, there was a smokelss fuel product which was very much in demand. Secondly, there was an old plant which created environmental disadvantages at the point of production. Thirdly, there was a nationally owned industry which was held to very tight financial limits by the government. He did not need to remind delegates from local authorities what tight financial limits meant at that time. Somehow or other the difficulty had to be resolved. If the plant was closed down, the product could not be produced. If the plant was rebuilt, the industry would fail to observe the financial limitations put on it by government. So it really required the judgement of Solomon to know what to do in that sort of situation. The NCB were doing the only thing that was felt to be possible in the light of government's refusal to make funds available, which the Board had thought would be the best answer. The Board were conducting plenary discussions with the union, with the consumers and with the local authorities to see whether some solution to the problem could be found. He could not state it more clearly than he had done already. That was the problem and a way out of it had to be found at once.

COUNCILLOR MRS. RUBY PATERSON (Edinburgh) said that she felt very concerned about the disposal of radio-active waste. Dr. Roberts had said tests had shown that deep geological strata were considered most suitable for that purpose. She wanted assurance that there was no movement in those formations. She asked whether it was positively known that

there were no underground waterways, and also, in the event of technology being developed, then or in a hundred years time which could make that waste less dangerous, whether it could be retrieved.

DR. ROBERTS thought that two things needed to be said. First, the management plan for the high level waste was most certainly not to bury it for quite a long time. There was no doubt that much technological advantage would accrue if the glass blocks were to be stored in the sort of store that he had illustrated on one of his slides, in which form it could be monitored and examined and retrieved as necessary for a quite considerable period - and he was talking of decades. There was as yet no plan in the UK to commit such waste to geological formations or any other form of disposal, before that type of disposal had been researched and examined most thoroughly with the very questions that had been raised in mind. The first question was the stability of the geological formation and the second is the hydrogeology - the question of whether any water movement from groundwater at depth could reach the surface and how quickly it might do so. The Government was sponsoring a research programme aimed at determining just those factors and, in parallel, aimed at determining whether it would be preferable or not to use the deep ocean instead of a deep geological strata. Government ministers had said that they did not expect to make a definitive choice for something like 10 years. He thought that Mrs. Paterson could therefore be assured that by the time such choices were made, the questions that she had raised would have been dealt with in great depth.

COUNCILLOR A. W. DOWNES (London Borough of Tower Hamlets) addressed his questions to the panel as a whole. First he asked whether, in the light of all the developments talked about that day, and the necessity of preserving a balance between the various fuel industries and environmental industries, it was really possible to do that without having some kind of command economy. He wondered whether it could be done in the current atmosphere of a free market. Secondly, referring to the necessity of bringing about interrelationships between the various fuel industries, he said that it would require, as had already been said, a great

emphasis on planning and, in the current political atmosphere, there seemed to be an argument against that. The majority of consumers did not seem willing to accede to authority the degree of planning that was necessary for the rather drastic measures that might be required. Thirdly, he asked whether, if there was a vast increase in nuclear power, the present safety margins would have to be revised. In the light of the subjective emotional and political factors which surrounded the issue he wondered if it was possible at that stage really to get an objective judgement on what was a very emotive issue.

SIR DEREK EZRA said that the first question had been really that under current arrangements, there was no declared national strategy or plan for energy, and could it be assumed that there would be a proper reconciliation between the supply of energy needed on the one hand and the environmental standard that was required on the other. His answer was that, from the morning's presentations and the afternoon's discussion, it was apparent that there was a very serious concern and interest on the part of the individual industries to do what they could to conform to environmental standards. They were doing that, first of all, because the UK was a crowded island and everyone was affected by everything that anyone else did. Secondly it was also done out of self interest. If the environmental problems were anticipated, there would probably be fewer impediments to progress in the industry's affairs. In the United States, per contra, the environment had been ignored for years until suddenly it had been decided that there was such a thing as the environment and the authorities had started applying policies which had virtually stopped any progress in energy at all. That was not a desirable sort of situation for the UK, providing that it could be assumed that the energy industries would continue to be very environmentally conscious. But he would not disguise his personal view that it could be helped on by a common energy strategy.

MR. BAXENDELL said that the problem could not be dealt with purely on a national basis. It was really a world problem. Distribution of energy and the importance of energy, particularly the fossil fuels, affected the entire globe.

There had been brief reference that morning to the different problems of the producing countries, the developed countries and the LDCs. That diversity was typical of the complexity of the problem and he found it very difficult to visualise "a sort of command organisation", which would be capable of overlording the whole world scene. There was a need for national policies, obviously; particularly on conservation and environmental matters. But the complexity of the world problem went way beyond that.

MR. G. A. W. BLACKMAN thought there was a great attraction in a grand plan in which all the pieces could be fitted in like a jigsaw puzzle, with a strategy to optimise the whole scene, provide the most economical solution, which would involve using a particular fuel in the home or in industry. He had been to countries which did in fact approach their task in that way. However, he could only look at planning within the compass of his own experience, and the CEGB planners were no fools. They had spent years in their chosen profession, planning what needed to be done to meet the future, and even they had frequently been wrong. He said he would loathe the thought of the UK having a master plan, and getting it terribly wrong. The best chance lay in the various industries pursuing their own futures in the knowledge of the pressures, particularly from environmental consideration, and doing so in the full knowledge of what everybody else in the energy sector was doing. Public pronouncements that were made all the time about the aspirations of the various energy industries, publication of corporate plans, etc. made the whole scene much more transparent. He very much preferred to work in harmony with other energies, while doing his own thing, rather than under an all-embracing plan developed by planners whom he would probably never meet in his lifetime.

DR. ROBERTS, replying on the question of whether the standard nuclear programme or the safety margins would have to be revised, thought that it would not be necessary. He was quite confident that the sort of expansion in nuclear power that he had been talking about could be put through with a continuation or even an improvement of the safety philosophy that had already been adopted. The question of whether

objective judgements could be made on such an emotive issue was a very important one. The type of information that he had discussed that day was, he hoped, the sort of information which would allow rational and not emotive judgement to be made on matters of safety policy. When standards had been proved already to give very good results, to require that they should be even better was a true waste of resources, even from the environmental and the safety point of view. If people were really interested in saving life, they would apply their minds to improving motor cars, and not to the further improvement of nuclear standards in the UK.

COUNCILLOR PHILIP JONES (Leeds City Council) commented on the difference between the transport containers being used in tests in New Mexico; one was cylindrical and the other appeared to be cubic. He asked how safe the containers currently in use in England were, what tests were being conducted on them and what tolerances had been allowed. He was particularly concerned about their use in rail transport, the variety of accidents that could happen by rail, or terrorist action. Secondly, he asked what the consequences of a breach in one of these containers would be upon an urban community, both in the short-term and long-term.

DR. ROBERTS said that those containers were of different design from those used in the UK but they were designed to the same standards and the same criteria as the ones used in the UK. Those criteria were internationally accepted. They had been promulgated some years previously by the International Atomic Energy Agency and as part of that regulation, the IAEA insisted on containers being shown to survive a whole set of rigorous tests involving dropping from heights, being exposed to temperatures of 800°C for half an hour, being immersed in water, as well as other tests. The containers used in the UK were designed to those standards and the standards were checked by a series of model tests, usually at quarter size, which were quite comprehensive.

There was, therefore, little doubt that the containers used in the UK would have gone through the New Mexico tests shown on the film, just as successfully as the American ones. Councillor Jones had asked also what would happen if con-

tainers breached. Dr. Roberts said that a great deal of work on that aspect had been done by the CEGB. The results had shown that if, by some very great mischance, there was a small break, nothing would happen except a leak of some mildly radioactive water into the immediate environment. If an even more unlikely larger breach occurred, there would be a considerable period before any larger release of radioactivity could occur and enough time therefore for remedial measures to be taken.

MR. BLACKMAN said that Mr. Roberts had described the scene as it was. Throughout 24 hours of the day the CEGB had people on call who could go to any train accident anywhere en route, people who were trained in that particular process. The CEGB could not envisage there being any need for them, but it was right to have somebody available who could be on the site immediately to make such assessments. There would be nothing to do for quite a long time, even with a breach, and at the end of that time, some cooling would have to be provided. That was rehearsed, and the CEGB operatives knew just how to do it. But he emphasised that the caskets in which the material was transferred were immensely safe. The CEGB had not carried out exactly the same tests as the Americans but the caskets were designed to exactly the same conditions. Although they differed in geometry, they did the same service.

MR. L. JONES (Rhondda Borough Council) referring to the Aberdare Phurnacite plant, said that he was involved locally both as a member of Council and of the NUM. The colliery where he worked sent 80% of its production to the plant. He therefore had a vested interest. He thought that the greatest single need was for co-ordination of energy policy. There had been no consistent government policy on energy. In the 60s there had been the energy trap of living in a world of make-believe cheap oil; then, in the course of 18 months there had been four major increases in the price of oil. From 1970 onward, the message had begun to be that there was not enough oil; then suddenly there was a home based surplus to requirement. It made the mind boggle.

He was still apprehensive about nuclear energy. He had been

privileged, 18 months previously to be one of a delegation of seven that had travelled in the States to see the US mining industry, how miners lived and how the industry affected the environment. He said that if the safety of their nuclear industry was anything like that of the US mining industry, it would be an appalling failure environmentally. Strip mining was carried out on a huge scale in America. His team had gone to Tennessee, Kentucky and West Virginia, and they had seen massive valleys, bigger than the Rhondda and Aberdare Valley where the Phurnacite plant was, being raped on a four foot seam of coal with a hundred foot of sand stone and lime above being blown off. The Americans could blow it off and produce that coal at a profit, to the great detriment of the environment. The coal industry in America, which was privately owned, had taken the US Department of the Environment to the High Court because they did not want to restore the environment which they had raped to an extent which had to be seen to be believed.

Councillor Jones thought that the speakers that day had put forward a wonderful case. However, he wondered how many members and officers of local authorities would be convinced by it. The Phurnacite plant at Aberdare also had to be seen to be believed, because it caused a huge yellow cloud above the town. A few miles away from there was an everlasting memory of the environment which went wrong, Aberfan; tip waste which had been a legacy from the old coal owners of years ago, had come down and killed well over 150 men, women and children. That was the environmental legacy South Wales bore, and while he thought that the Coal Board were trying to do something for the environment, he said that until such time as the various energy industries stopped fighting one another in public, and joined forces, the wider problems could not be rationalised and solved.

<u>SIR DEREK EZRA</u> said that, as far as the coal industry was concerned, everything Councillor Jones had said was absolutely right. The UK mining industry had, he was glad to say, the highest safety standards of any comparable industry in the world. The UK was also way ahead of others on restoration of opencasting operations. It was good to know that the UK industry were leaders in some areas, at any

rate.

MR. J. R. P. EVANS (Rhymney Valley Borough Council) said that the policy of declaration of smoke control areas had never been undertaken by South Wales authorities, due in the main to the fact that for years, domestic coal with a low bitumen content had been mined and used in the area. Unfortunately, in recent years, there had been a growing tendency for English coals to be imported into the Principality for use as domestic fuel. The English coal, being of a high bitumen content, was certainly not suitable for smoke control areas. With the present setback in local authority's finance, he very much doubted whether South Wales authorities would put finance aside for a policy of smoke control. He asked whether the policy of importing English house coal could be stopped and locally mined coal used.

Secondly, he said that Sir Derek, in his paper that morning, had painted a rather rosy picture for the future of the coal industry, for the development of the Selby coalfield, and possibly the Belvoir field, together with upgrading of existing coal mining. He asked Sir Derek what he saw as the future of the South Wales area for the NCB, taking into account the heavy reliance on the supply of coking coal for steelworks in the area which had suffered production cut-backs and possibly the closure of plant, together with the high production costs of South Wales coal.

Finally, he asked Dr. Roberts whether there was any need for the implementation of spent fuel rods reprocessing in the UK.

SIR DEREK EZRA, answering the first point about the importation of English house coal, bituminous coal, into South Wales, said that NCB coals were sent wherever they were needed. If more Welsh domestic fuels were to be produced, which was being attempted, it would not be necessary to import English coal. But, from time to time, England needed to come in and help Wales, just as from time to time Scotland needed to come in to help England, or vice versa. The NCB operated a single mining industry, which he thought was the right way to run it, and the industry had to move coal

around according to need. They tried as far as possible to meet customers' requirements but there were times when other coalfields had to augment the supply.

Secondly, on the question of how the South Wales mining industry would be developed, Sir Derek said that South Wales was a very old coalfield, one of the oldest, producing some of the rarest coals: the high grade anthracite, the prime coking coals, with very low sulphur content and so on. However, markets changed and geological conditions changed. South Wales was having to go through a process of adaptation to those changes. The Board, as the management, were trying very hard to work with the unions to bring about that adaptation. Life changed, and things could not continue in the same way indefinitely. The mining industry dealt with geological conditions and had to face up to the fact that the mines, in some cases became exhausted, or that the geological conditions worsened. In South Wales the Board would go for the development of those conditions which were most propitious. Markets would progressively have to adjust to the fact that the coking requirement was going to diminish. Arrangements had been negotiated with the steel industry which would safeguard the position for the next two years. And the Board would have to see how they could go beyond that. In that period the industry would have to be adjusted. He was sure it could be done; it was a challenge - and that was what industry was all about.

DR. ROBERTS said that he thought the reprocessing of spent fuel in the UK was the most sensible, technical and economic course to follow. In a nutshell, recycled uranium was needed for the economy of the current nuclear stations. It was hoped that plutonium could be burnt in future stations to promote valuable fuel conservation; and reprocessing actually gave the most convenient and the best understood method of handling the radioactive waste. The question of reprocessing had been rehearsed at length at the Windscale enquiry for 100 days before Justice Parker before the decision had been taken to allow the design of a new reprocessing plant at Windscale (Thorpe) to go ahead. He could not hope to summarise Justice Parker's report at that time, but he thought what he had said was quite compatible

with his findings.

COUNCILLOR TOM HARRIS (Mansfield District Council) asked Sir Derek about the future environment of mining, and the problems of subsidence while having intensive mining under densely populated areas. He felt that they had a particular problem in Mansfield, especially where he lived in Mansfield Woodhouse, where several seams were going under the district one after another. Knowing that the financial pressures on all authorities and public utilities was causing undue criticism, he nevertheless felt that the problem of deciding what responsibility or what level of financial responsibility, in the putting right of sewers and water mains damaged by subsidence, sometimes left the problem with the people a lot longer than necessary. Expensive emergency repairs to the environment had been done while public utility authorities and others were consulting about their financial input. He had every confidence that the Coal Board would put things right, but the length of time that people were really subjected to the subsidence problem could be shortened.

SIR DEREK EZRA said that it was another one of those issues where a degree of compromise was necessary. Subsidence could be avoided completely if no coal was taken out at all. Therefore, in every case a decision had to be made as to how much coal was taken out and how much subsidence was socially bearable. The industry had a responsibility under the law to make good any deficiencies that arose as a result of subsidence but mining meant taking something out of the ground, so there was bound to be a degree of subsidence. The industry sought to control it in the interests of producing the coal at prices which people were prepared to pay.

SESSION 3

NOISE

ENVIRONMENTAL NOISE CRITERIA

Professor J. B. Large, Institute of Sound and Vibration Research, Southampton University

THE ROLE OF THE LOCAL AUTHORITY IN THE CONTROL OF NOISE

Mr. G. Charnley, Environmental Health Department, City of Southampton

COMMUNITY RESPONSE TO NOISE

Mr. C. R. Cresswell, Environmental Health Department, Newcastle upon Tyne

MR. P. E. BAVERSTOCK (Eastbourne Borough Council), opening the discussion, referred to a speaker the previous day who had very eloquently warned the Society against going in for compromise, as he had interpreted the word 'balance'. Mr. Baverstock felt that balance did not necessarily mean compromise; what he thought the Society should do, and indeed what many environmental health officers strived for, was to achieve a balance by getting the other fellow to compromise. Balance and compromise, in his opinion, were both involved with the matter of equilibrium. Noise and noise nuisance went back to the days in litigation where what was equitable was what was decided in respect of balance and equilibrium. Professor Large had referred to balance when he had used the phrase 'what was unacceptable in noise levels, what was acceptable, and what was desirable'. Mr. Baverstock thought that environmental health officers and the Society should aim, not for what was acceptable, but, higher than that, to achieve what was desirable.

Mr. Charnley had also advocated balance when, in his paper, he had written: "a sprinkling of noise of the right kind can add spice to what is otherwise a monotonous acoustic environment". Complaints alleging unacceptable noise, as had already been stated in the papers, were on the increase, and Mr. Baverstock hoped that the Society, and his own profession, had risen to the challenge posed by that

increase. Helped by circular 10/73, Planning and Noise, the Control of Pollution Act 1974 and allied legislation, he thought that much could be achieved. Much had been achieved in the past, and much still had to be achieved in the future in terms of noise control.

Flexibility, co-operation and co-ordination had been the keynote, not only between industry, commerce and local authorities, but on an increasing scale between different departments in local authorities. In the past, local authority departments had been very insular. With the advent of circular 10/73, and other, what he considered to be well worthwhile pioneering pieces of paperwork, local authority departments - environmental health departments and certainly planning departments - had got together, to the benefit of one and all. As an environmental health officer, he and his colleagues had suffered in the past from EEC directives, and he shared Mr. Charnley's fears, that such edicts on the subject of noise might very well hinder or even disrupt much that had been, and had still to be, achieved in the field. He thought that far more could be achieved by the informal approach than by being dictated to by the EEC, about what must, and must not, be done.

Mr. Cresswell had touched on the topic (as had Mr. Charnley) of sound insulation between dwellings. Mr. Baverstock said that he was particularly concerned about that, and knew that many other EHOs also had problems with sound insulation, or lack of it, between dwellings. It was compounded, in modern dwellings certainly, by the use of that euphemistic term, the 'deemed to satisfy' clause in the Building Regulations, about which he felt that something ought to be done. Builders understandably wanted to make as much profit as they could; profit margins were being slashed continuously because of rising costs, and in order to keep their profit margins reasonably buoyant, builders cut corners and inevitably sound insulation between buildings suffered. One particular complaint he had become involved with concerned a terraced house of about 2 years of age. The complainants had said that they could hear everything that went on in the house next door. Mr. Baverstock had confirmed that when he had gone into the kitchen; he had heard the kettle boiling

in the kitchen next door (as well as the switch being thrown) and a somewhat embarrassed complainant had said that the situation also prevailed at the first floor bedroom level, with attendant amusing consequences.

Someone had once said words to the effect that we are only caretakers of the present, for the generations of the future, and with that in mind, he asked the speakers what they each saw as being the principal noise problems of the future, and what they thought would be the trends in future noise control. Finally, he remarked that some said a dog's bark was worse than its bite; he asked the delegates which they would prefer, to be barked at by a dog, or to be bitten by one.

MR. R. WESTERMAN (Nottingham City Council) thought that life had got very complicated. He looked back 25 years to the time when, as a student, law had been made in England and not in Brussels, and when if it didn't appear in Clay's Handbook, it did not exist at all. He thought that one of the advantages of coming to such a conference was to hear other people's views and problems, especially in the field of domestic noise. Society, he said, had created a monster, a Frankenstein, that was affecting itself. If one looked at the domestic noise situation today, and the figure that Mr. Charnley had quoted could be repeated up and down the country, there was a tremendous increase in the number of complaints coming to the local authority departments. Partly, the problem had been exacerbated by the success of his own profession, which had cleared the slums, and with the building of high-rise flats in their place, high density flats, deck access and so on.

People might wish to churn out music at 40 watts per channel, in the comfort of their own homes; however, if that was done in some of the modern complexes, the disruption to the neighbours was beyond belief. In certain cities, and Nottingham was one of them, there were noise problems associated with, amongst other things, ethnic minorities. The West Indians in particular were an exuberant race, and when they played their music, or had their shebeens, the noise could be quite considerable. Noise from music was

also often associated with drugs, the sale of alcohol and prostitution, and because of those factors, EHOs had to work very closely with the police. The Environmental Health Department was not really concerned with some of those things, of course, and the officers would often say to some of the girls involved 'we don't mind you doing it, dear, but would you mind being a bit quieter while you're at it'.

Something that the Nottingham EHOs had had to tackle a short time before, had been an old cinema which had been hired by the West Indian community (and that had happened 3 or 4 days after the St. Paul's race riot in Bristol). The EHOs had had to spend about 8 hours on all-night surveillance (they had taken a house over, together with the police) and they had heard that some of the Bristol contingent were going to pay them a visit and the amount of co-operation that had had to go on behind the scenes between the Chief Constable and the Chief Executive had been considerable. Many EHOs would have attempted to investigate such problems at 2 o'clock in the morning; having first politely brushed off the attention of the ladies of the street, and having sent them packing, they would then have to enter buildings (in twos) to try to sort some of the problems out. Mr. Westerman asked the speakers what they would do in such circumstances, and what they saw as the problems. He wondered if health education was one answer. Certainly, summary proceedings under S.59 of the Control of Pollution Act was no solution. In view of the trouble, with the dogs out and the petrol bombs in Nottingham a few weeks before, he did not think that his department could really invite any of the neighbours to go and serve a summons on the fellow next door. He wondered if there was any prospect of sound insulation working in that type of concrete construction, which he thought had been designed by jigsaw manufacturers rather than architects. Secondly, he wondered what was the reason for the rise in complaints. Was it because the law was more available to people, or that they knew more about it, or was it the great stress that there was in society today which made people far less able to cope with noise, which of course was a stress factor in itself.

PROFESSOR LARGE, referring to points from the floor about

the EEC and EEC regulations, said that in his opinion that was perhaps the biggest problem in the field of noise control; the conflict between our laws, not just those of the UK, but the laws that were developed in those countries which had a basis in English Common Law versus the codes, the regulatory process, followed in most European countries, which was of course also being promoted in the direction of environmental noise control. Until there was some sort of resolution between the common nuisance practice of the English-speaking countries versus the regulatory approach of the European countries, there would perpetually be a conflict with EEC regulations (whether they were noise regulations or any other sort of regulations). He was not sure in fact which was right. There was a great deal to be said for the British and the American approach, which appeared to be on the face of it a very democratic idea of asking people how they felt about noise, but it did pose all the problems that he had tried to highlight in his talk, by showing that it produced an answer with a great variety of directions in which to go. Whereas the European approach, particularly the French approach, which now appeared to be the model, was a more theoretical, scientific approach, in which, for example, sleep would be taken and the regulations based upon the sort of physiological effects that the scientific research had shown; whether there was any variation above the norm was a matter of debate, but rules would be set that way, rather than on the basis of social survey, which always produced a rather low correlation between response and stimulus.

Turning to the subject of domestic noise, he said that it was a very interesting problem. For example, with noise within the kitchen, there appeared to be a difference between the response of the user of the equipment, i.e. the housewife, and the listeners, i.e. the husband or the person next door. He did not believe there was any great difficulty in educating the public to be more responsive to quieter domestic equipment. He believed, in spite of all the discussion there had been on the subject, that a labelling system that could be applied to domestic appliances could be produced fairly simply. There had been a great deal of discussion as to whether the population was sophisticated

enough to tell whether 5 decibels lower noise level for one product was significant or not. He did not think it important when one considered all the scales that were used in daily life - Beaufort scales, temperature scales, scales for speed for film, oil viscosities etc. These were used quite normally without it being necessary to understand the technical details. People learnt through experience the significance of an incremental change from one number to another, and he thought that that could be learnt very readily by the buying public in relation to noise; if they found that a vacuum cleaner was 5 dB quieter than another vacuum cleaner, they would soon come to know in practical terms what that 5 decibel difference meant. Great progress could be made in that direction through a labelling system that would clearly identify the type of noise output.

Turning to the party scene described by Mr. Westerman, he said that there was no way on earth that one could ever produce sound-proofing of economic reasonableness in any structure that would prevent the noise of a drum or the noise from a hi-fi system penetrating through the walls or floors of a building - it just could not be done. Even if the noise were reduced to what would appear to be a reasonable acoustic level, the misfeasance characteristic would still come into it - that people did not want to hear the noise anyway because it had a social connotation. So the act of hearing that activity, at whatever level it occurred, would also evoke complaints and response; he had no solution to that - all that could be done was what had been done, to try and convince the makers of the noise that it was an anti-social act, even though it might be, in their opinion, some sort of suppression of cultural dimension. They were now living in a society having some rather different demands placed upon it and they had to evoke a sense of responsibility in seeking to comply with those laws as well. In summary, he did not think that there was any physical solution, such as sound-proofing; he thought it was a matter of education and social responsibility.

MR. G. CHARNLEY said that on the domestic noise scene, it might be of interest to know that the EHOA Annual Report for 1979 showed a 33% increase in domestic noise complaints in

1979 over 1978. To some extent he felt the solution lay in people becoming more considerate and being more tolerant; there were also, possibly, associated problems with education. As soon as people were asked actually to listen to the noises they heard, they latched on to them and those noises could well become annoying, so education could be both productive, and possibly to some extent counter-productive. As far as ethnic minority groups, shebeens, etc., were concerned, he tended to agree with Professor Large. He thought that people coming to live in the UK should adopt an attitude of 'when in Rome'. Possibly an answer to shebeens would be to confiscate their equipment, as was done with people caught fishing illegally. £400 or £500 worth of hi-fi equipment confiscated would hurt, although when a whole street was being kept awake all night, and there was the problem of not even being able to find out which person was actually running the party (as it moved from brothel to brothel week by week) it was an extremely difficult problem to resolve. In his own area, one community leader had led the complaints situation from householders in the neighbourhood and had stood up as their representative. Every time a shebeen complaint was investigated, that man had his car headlights kicked in and his tyres slashed. So there was a problem even in complaining!

As far as the EEC approach was concerned, he had heard the view generally expressed in the UK, that the policy of best practicable means was admirably suited to the general approach method. He had also heard another view, from Stanley Johnson, Euro-MP, that the setting of standards made the recalcitrant countries at least obtain some level of control where formerly none existed at all. So far as the UK's BPM approach was concerned, he thought that the EEC method of setting absolute standards could well be counter-productive.

There was, he thought, scope for labelling goods; he certainly would have liked to have known what noise level was going to be produced in his car at 55 or 75 mph, before he bought it. He had bought it because it had been aero-dynamically designed and advertised by the manufacturer as good at high speeds and so on. He was very pleased with it

but it would have been nice to have had a label on so that he could have known a little bit more about the acoustics design side.

PROFESSOR LARGE gave an insight into ethnic differences from another standpoint. His own experience over the previous 10 years, in carrying out noise surveys in a whole variety of countries: Iran, Greece, South America, USA etc., had produced some rather surprising results. His finding was that in fact people of very differing cultural backgrounds tended to behave in a very similar fashion. The differences tended to show up, not between cultures and not between races, but between different sources of noise. People seemed to react similarly to traffic noise in Iran and in London, or in Paris or in the United States; but they responded differently to aircraft noise. It was the source difference which seemed to set the level of annoyance rather than any ethnic or cultural difference. From that point of view, there had been a great deal of talk about Italians being more easy going and more able to accept noise than the French or the British - that simply was not true. There had been a survey, often quoted, carried out about 10 years before, in which a group of Swedes had been compared with a group of Italians exposed to the same level of traffic noise, and the analysis had shown that there was about a 10 dB difference - the Swedes, as might have been expected intuitively, had been shown to be more sensitive to noise - in fact that was not true, the analysis had been incorrect and a reanalysis had shown that the Italians and the Swedes responded almost identically.

MR. H. DAWSON (Rolls Royce) said that Professor Large had given an interesting dissertation on noise criteria but he had reminded delegates that the effect should really be considered in terms of people rather in simple numbers.
Mr. Dawson was therefore somewhat puzzled that Professor Large had specifically seemed to exclude the problem of low frequency noise - that is, noise certainly below 100 cycles per second and arguably below about 40 cycles per second. His company was the largest employer in a rather agricultural type area, and as a company which dealt with large noise sources putting out massive amounts

of acoustic power, if there was a noise going on within 10 miles of the Rolls Royce works, they were blamed for it, and they therefore spent a lot of time in co-operation with the local authority and the local residents in tracing those noises. There was nothing worse for an individual than feeling that he had been fobbed off by a large organisation; so they spent a good deal of time and trouble in identifying the source of noise with those people and getting them to agree on the source of the noise. Low frequency noise from domestic or industrial boilers, or large industrial fans, etc. created a lot of trouble. He was certain that a great deal of human misery was caused by low frequency noise, but that aspect had been totally excluded from all the present criteria and he wanted Professor Large to comment on what was being done to try and give some guidance on acceptable levels of low frequency noise.

On the question of physiological effects, he wanted to give an instance of what he believed to be muddled official thinking. There had for a long time been a number of advertisements put out on the television by a government agency which said "If you get tired on the motorway, open the windows". From the work that he and his colleagues had done, they believed that that advice was little short of disastrous. Already, in most cars on the motorway, there were very high levels of low-frequency noise - around 110 to 115 decibels, relative to 2×10^{-5} newtons per m^2, so that considerable noise pressures were involved. If a driver then opened the window when doing about 60 mph, that noise could increase by about 15 or 20 decibels into the driver's or passenger's ears and the effect could be very great and very dramatic. One could get nausea, leading to vomiting, disorientation, heart palpitations and a number of other things which had been adequately reported in the literature, because there had been a great deal of work done on the subject by the Russians and by UK agencies; yet that sort of advice was being issued.

PROFESSOR LARGE said that he had not avoided low frequency noise; he had ignored it, the reason being time more than anything else. His was essentially a talk on environmental noise; he had excluded the low frequency component and

vibration because he thought that that was a somewhat separate topic and in many instances more difficult to deal with. However, he certainly agreed that it was a problem, for a number of reasons. Low frequency noise propagated, travelled really uninhibitedly - it could travel for miles without any degree of attenuation at all. An aircraft would have a noise characteristic, at an airport, close to the boundary, of a certain type; the high frequency noise from the fans and the compressors could be heard. A mile or two away from the airport, a low frequency rumble could be heard because the high frequencies had attenuated and that was all that was left.

The problem of low frequency noise divided into two parts; there was the noise itself, which had a certain effect on people, but there was also the potential for the noise to cause vibration, because there were wavelengths of the order of 10 feet or more, the size of a human being, and also matching the dimensions of the buildings in which people worked and lived. From a noise point of view, low frequency, environmental noise undoubtedly had an effect on people. It added an extra factor into speech interference and that could be calculated fairly readily by taking into account the masking effects of low frequency noise; it certainly increased the annoyance, which was not allowed for in the normal dB(A) weighted descriptors, or the perceived noise level, to an extent which he thought had been ignored in the past and ought to be included. It also had the ability to travel through structures a lot easier than high frequency sound - the transmission path through even a thick structure was little protected from low frequency noise so it could get into the structure that way and ought definitely to be considered. But more important, in his opinion, was the effect low frequency noise had in its potential to induce vibration.

There were two types of vibration: the ground-induced vibration, via the waves travelling along the ground and arriving at it that way, or by the noise travelling through the atmosphere arriving at a structure and then shaking it, and low frequency sound had the potential for doing that. When a structure was shaken, it behaved in two ways: either

the whole thing vibrated, as in an earthquake or sonic boom, and the whole structure could be felt to vibrate, or there was secondary vibration, which was the more frequent and therefore perhaps the more important problem. It caused windows to rattle, dishes rattling on the shelves, pictures perhaps to turn a little bit because the walls had shaken, and that certainly was a problem as well. There were no adequate criteria for vibration-induced effects; there were standards, there was an ISO standard, which he believed was inadequate. There was really no suitable set of standards which would allow the effects of airborne and groundborne vibration, at low levels of vibration, to be defined, and he thought that a great deal of work had to be done in that area before that point could be reached.

Turning to Mr. Dawson's two other points, one had referred to what was known as a multi-stress environment, where a driver rolled down the windows of his car because it was too hot or he was getting tired, and then got noise induced through wind through aerodynamic effects. Certainly those things were additive in a rather subtle way. If a person felt stressed because it was hot, or because he was being vibrated, additional noise would add to that stress. So it did not help to open the windows, except that for a short period of time it would keep the driver awake in the fresh air, but it would ultimately add to general tiredness, because a further stress was being added. Although there had been a lot of information reported in the literature as to the effects of low frequency noise on people, when the information was examined in detail, the vast majority of it was anecdotal, and there was very little scientific evidence for nausea-induced effects, for physiological phenomenon - there was very little substance to that. But there were documented instances where some nauseous and physiological effects had been induced through low frequency noise exposure, but they tended to occur at very, very high levels of noise - such as in a space capsule, for example; and the general conclusion from the current state of information was that there only appeared to be a physiological problem due to high frequency noise at extremely high levels of exposure - 130 to 150 decibels. Below that, there might be some occurrence of effects, but that would be due to the great

scatter of response he had demonstrated earlier between individuals. It was something that rarely occurred and examination of information in magazines etc. revealed that most reported instances were hearsay or little more than that. His own feeling was that physiological effects would only occur at very high frequencies.

MR. M. O'BRIEN (Watford Borough Council) asked, in connection with domestic noise nuisance, what was Professor Large's view of the standard ear. He was always concerned, when officers from his department were sent out, that perhaps their hearing might not be the same. Therefore arrangements had been made with the DCP to have audiometric tests carried out on them, just to make sure that they could hear what they were going to hear. He wondered whether any other local authority did anything of that sort.

On the question of neighbour's noise, Mr. Charnley had suggested that S.59 should not be used. Where it was a one-to-one situation, one neighbour against another, then quite often the noise was only one aspect of the job: usually they had originally fallen out over parking the car, or cutting the hedge, and noise was one way of getting back at the neighbours. His department did not take any action on domestic noise complaints unless more than one household was involved, because they had got into a difficult position in the past in such one-to-one situations.

Mr. Charnley had also suggested that industry should be brought into the town. In a town like Watford, there could be a large warehouse: Watford indeed had a distribution depot and the company's method of working involved the use of a computer which, at 11 o'clock at night produced a schedule of which goods had to go to which shops the next morning. The men got roll-on, roll-off pallets, which were all nicely stacked, chucked them down on the floor to break them apart, and rushed round between 11 p.m. and 3 a.m. The warehouse was formerly owned by a firm called Standard Range who did boiler parts, and there had been only one wagon in and out, once a week more or less; now there were fleets of lorries loading and unloading, and actually the ISVR were called in as consultants by the owners to try and sort out

the problems. However, the Watford Borough Council had solved the problem very easily; there were loading docks at front and back, so the environmental health department had said that the back was not to be used at all at night-time. There were still problems in the daytime because the houses were very close by, but one had to use a bit of commonsense on such jobs. He said he would like to see industry, and particularly warehouses, sited well away from housing. At Radlett, the old Handley Page Airfield had been developed into a large warehousing complex. It was well away from everybody and not causing any trouble.

Mr. Cresswell had spoken about the question of burglar alarms. Mr. O'Brien said that it was not the job of the police to turn the burglar alarm off, and he did not want them ringing him up at 3 o'clock in the morning to turn the alarm off. If the police could not find the keyholder, there was nothing the EHO could do. Next day, by all means, he could get on to them and say 'get your keyholder sorted out' but there was little point in going out and soliciting complaints at 2 or 3 o'clock in the morning.

MR. G. CHARNLEY replying, said that his point about S.59 in relation to complaints of domestic noise nuisance was that it was difficult to use. The law would rarely provide a satisfactory solution to next door neighbour noise problems. The approach adopted in Southampton was to go and see the complainant and find out what his side of the story was. The EHOs would explain to him at the time what the law provided, what the law might expect him to tolerate, in terms of nuisance in the legal sense; the EHOs would also go, without establishing that there was actually a noise problem, and put the case to the person about whom the complaint had been made (if the complainant still wished them to do that). When they went to see the person who was the subject of complaint, they set out the details of the complaint, as made, and asked for the other side of the story; they also explained that person's rights and duties under the law, and later followed up both visits with standard letters which reiterated the legal provisions. In that way, the majority of domestic noise problems were, he thought, alleviated. The Environmental Health Department

did not hear about them any more: whether that was a solution or not, he could not tell. He felt that it could have explained the nuisance situation, but that the complainant might still have been left with some degree of annoyance. He was not saying that that approach was the right one but it was the approach which Southampton and its members had adopted when dealing with domestic noise of that type.

So far as the company at Watford were concerned, he had tried in his paper to advocate the location of suitable development in the area, bearing in mind what other development was alongside it. If planners had allowed Sainsbury's to go ahead, and had not considered the consequences, or asked Sainsbury's whether they were likely to be chucking pallets about at 3 o'clock in the morning, then he suggested that the planners had not done a proper job from the outset. (From the floor, Mr. O'Brien said that there had been no change of use, the premises had been a warehouse before; therefore planners had not come into it.) Mr. Charnley said that if it was existing warehousing in the first place, then only the nuisance provisions of the Act were left; and Watford had chosen to adopt them. He could not see any conflict there with the comment in his paper on planning consent conditions.

MR. CRESSWELL said that on the question of burglar alarms, it had not been his recommendation at all that the police should telephone himself or anyone else in the early hours of the morning; the idea was for the police to tell the EHO the next day that a keyholder had refused to turn out; the EHO could then take the matter up with the keyholder himself, or the owner of the property, and try to ensure that he or she was aware of their obligations to people who lived in the area. If the person was particularly awkward about it, that was the time that he wished to insist, by notice, that they put in the cut-out device, so that the alarm would cut off after 20 minutes.

PROFESSOR LARGE was uncertain what was meant by the 'standard ear' but said that if a subjective test was being carried out on domestic or any other sort of appliances or

noise sources, it was imperative that the subjects responding to those noises were a statistical cross-section of the population who were exposed to the noise; they should have characteristics that represented their hearing, their social background, whether male or female, young or old, etc., otherwise the information was biased. Proper experimental design was highly important in a situation like that. Someone had referred earlier to the business of carrying out social surveys; Professor Large said that any idiot could put together a questionnaire; but a questionnaire that could be analysed and the information used in a scientific sense to discern the magnitude of a problem was a highly skilled proposition. His own experience in carrying out surveys of domestic appliances was that not only was a representative of the auditory side required, as a respondent, but also that appliances had to be examined in terms of both the user and the listener, and the environment in which the noise would occur, e.g. the kitchen versus the living room. All of those factors had to be designed into the experiment.

MR. S. G. CARDEN (Barnsley Metropolitan District Council) said that none of the speakers had made much play on B.S. 4142 in their talks. B.S. 4142 was the British Standard method of rating industrial noise and it was one which, as Professor Large had said in his written paper, was a favourite with local authorities. Mr. Carden felt that B.S. 4142 was long-overdue for revision, and that it provided a poor and inadequate standard. Those local authorities which had tried to use it in the Magistrate's Court, and been unsuccessful, would agree with him. It was particularly difficult to use the derived notional background level: it was indeed perfectly possible to arrive at an extreme situation, where there was a well-established factory in an industrial area, working by day, and to finish up with a derived notional background level which approached the realms of noise-induced hearing loss! He felt that the standard was most inadequate. The basic criterion of 50 dB had been set by the London Noise Survey in the early '60s and was way out of date, based on a small amount of hurried research carried out in a city area.

Mr. Cresswell had touched on opencast mining problems in his paper. Mr. Carden said that in mining areas, such as

Barnsley, it was possible for the NCB to work coal, on opencast sites, at a far lower cost than with deep mining techniques. The previous day delegates had heard a great deal about the world energy situation and the need for a balance between environmental protection standards and shortages of energy. However, at a local level, people facing a particular environmental problem found it difficult to appreciate the complex ties of the world energy situation, or to realise the need to balance environmental requirements against energy shortages. Mr. Cresswell had mentioned the vague and generalised conditions which the Secretary of State had put on authorisations for opencast mining. In some of his most recent authorisations, he had put a specific noise level, a sound pressure level based on Leq, not to be exceeded at the boundary of the site. Those levels were in the region of 65 to 70 dB(A) as measured over a 12 hour working day between 7 a.m. and 7 p.m., at the boundary of the site. A 70 dB(A) Leq over 12 hours, 7 o'clock in the morning to 7 o'clock at night, added up to an awful lot of noise. If figures were set much lower than that, then the contractor had difficulty in working, so again there was the conflict between energy and environmental needs, and usually the Secretary of State had exempted certain operations, of splitting topsoil and overburden which were extremely noisy operations involving very heavy plant, from that Leq provision, so in practice they could make even more noise than that. Mr. Carden asked whether Mr. Cresswell considered that Leqs in the region of 65 - 70 dB(A) at the boudary of the site were reasonable.

PROFESSOR LARGE felt strongly on the question of B.S. 4142; he thought that the standard had been stretched to the limits of credibility. It was long overdue for revision; the problem was, how to do it. An example that he had come across recently was the use of 4142 for airports' design; that, he thought, was completely out of context. Two problems were the wide range of uses to which a standard of that sort was put; people judged aircraft noise differently from traffic noise and there should be some recognition of that in such a standard. The other, perhaps more important problem, was the way in which multi-source environments were judged, because there was not simply one activity, a drop

hammer or any other single source, taking place in a complex environment, there was a whole multitude of sources. Very little indeed was known about the effect of multiple sources and the way in which people reacted to them. In the previous 20 years, the emphasis had been on trying to find solutions to single sources of noise. There were beginning to be some very interesting results: where there were two sounds of equal intensity but of different character, people had great difficulty in judging the annoyance, and it was even worse when there were three or four sounds. They could make a judgement very easily when the sounds were of different intensity, but something has to be built into the standard which acknowledged that fact. Its international counterpart, ISO 1996, was going through the whole process of revision. The revised document expanded the workload by 10 orders of magnitude. It would, even for a simple environmental impact statement, expend the entire annual budget to follow the 1996 revised prescription. The changes were absolute details based upon no real scientific evidence at all, most of it intuition as to the way things should be, and perhaps either right or wrong. He believed great care should be exercised in the use of B.S. 4142, and ISO 1996, and that any revision that took place in either of those documents should be carefully constructed in the light of what was known versus what was thought to be known and thought to happen.

MR. CRESSWELL thought that the 70 dB(A) 12 hour Leq was very high indeed. What bothered him particularly was the consideration which was being given at that time to including opencast mining in the Code of Practice 5228. He would rather have had much more discussion between the affected local authorities and the NCB, on a national scale, to arrive at an acceptable standard.

MR. F. REYNOLDS (Leeds City Council) said that the trouble with speaking close to the end of the session was that the thunder had been stolen, not once, but even two or three times by colleagues from the floor and speakers on the platform. Therefore, two or three of the points he had been going to raise had already been covered. But he wanted to comment specifically on BS 4142; when it had first been

developed, it had not been intended as an assessment of whether or not there was a noise nuisance, but it had been intended as an assessment for whether or not a new noise source would give rise to complaints. There was a suggestion in the British Standard that an increase of 5 dB would cause minimal problems amounting to no significant increase in complaints, whereas an increase of 10 dB(A) would cause considerable community response. The implicit assumption was that an increase of 5 dB was of no significance - but if that were to be repeated at several sites, there would then be a creeping background noise situation. In that context, he referred to the psychology of noise complaints. He said that the British public were generally pretty tolerant about noise problems and would tend to tolerate a slight increase in noise levels over a period of several years, until something happened - a bearing became faulty and produced a screeching noise or a new piece of equipment was installed which produced a discrete tonal frequency. When something different happened which drew the attention of the public to the general noise climate, complaints followed. The complainants did not merely want the new noise component to be removed, they wanted the whole of the acoustic environment attended to and reduced to what it had been several years ago, and that was something which BS 4142 was incapable of assessing. For that reason he agreed entirely with what had been said.

DOE Circular 10/73 had been mentioned, but it had not been explained that it was due for revision although he knew that some of his colleagues on the platform, and others, had in fact made comments on it to DOE. There was to be a meeting of the Noise Advisory Council Law and Administration Group the following week, where he believed that 10/73 would be back on the agenda. What concerned him was not so much what 10/73 said now or even what it might say in the future; more the current idea that there would be relaxation of planning controls for certain inner city areas with the potential for virtual freedom of development. Unless the Government was very careful, there might be a reversion to the conditions of 20 or 30 years before in certain areas of cities and towns, with mixed industrial/residential development produced for short-term political expediency for the generation of

jobs, but with the long-term effect of serious detriment to the environment. There again, a balancing act was required. The choice had to be made between curtailing the development of new jobs in an area by attempting to control new development very critically or letting development go ahead uninhibitedly.

Finally, Mr. Reynolds commented on opencast coal-mining. He said that Leeds had some large opencast sites, particularly in the south-eastern semi-rural areas where there were also a number of villages and settlements nearby. The Council had just received information that the Secretary of State for Energy had confirmed another very large opencast coal site and had stated that the overall need for coal outweighed environmental considerations. Fortunately, the consent had been accompanied by some stringent conditions, but those had had to be squeezed out of the NCB before Leeds and the West Yorkshire County Council had been prepared to withdraw their objections to the development, which they had seen was going to be approved anyway. The point was that they had had to squeeze the conditions out of the NCB and, had they not done so, the Open Cast Executive would not have volunteered them - they had been prepared, in the absence of objection, to take everything and give nothing. Mr. Reynolds said that the NCB was a thundering great juggernaut. The previous day, delegates had had the opportunity of hearing Sir Derek Ezra, the human dynamo, who was the originator of the juggernaut and in the driving seat; Sir Derek had made it clear that despite having his NSCA presidential hat on for part of the time, he was going to ensure that the coal industry forged ahead with opencast mining, deep mining, drift mining or whatever to such an extent that Mr. Reynolds feared that the environment in some UK cities was going to be despoiled for at least another 20 years until the end of the century and that some abysmally difficult problems would have to be resolved as a result.

MR. C. G. HOWELL (S.W. Division, NSCA) said that the Department of the Environment was asking for views on the early application of the Secretary of State's powers under S.68 of the Control of Pollution Act. That section provided for the making of regulations to reduce noise from plant or machinery

and reducing the level of noise from construction sites. He wondered whether the ISVR commented as an interested party, and if so, what its views were, and how it would like to see the regulations formulated. He asked Professor Large what sort of indices he would advocate. Mr. Howell said that his own district of Stroud was not alone in having many industrial and domestic noise problems. Most, if not all, of those were capable of solution. Admittedly, some were in the grey areas between extremes, and usually, as Mr. Charnley had mentioned in his paper, when the law of diminishing returns began to operate. He was, however, convinced that despite statistics regarding actual complaints, the greatest social evil in noise pollution was caused by road traffic, whereby 23% of the population was subjected to nuisance.

Whatever Highway and Planning authorities were able to do in their structure plans and transportation policies to reduce noise at the design stage, however admirable those were, went nowhere near far enough to deal with inner city and suburban problems. Grants for insulation work to existing dwellings did nothing at all to improve the outdoor environment. Legislation to exert pressure on the already hard-pressed motor industry might not be popular with governments today, but he thought that there surely ought to be more action by the EEC to persuade motor vehicle, freight, body and car manufacturers to pay more attention to research into the problems of noise, particularly from the continental type juggernaut and the quite unnecessarily noisy, low powered, motor cycles so prevalent on the streets. Their efforts would, he submitted, be better employed on those matters than worrying about standards for motorised lawn mowers. The best that could be hoped for seemed to be about a 5 dB drop in 10 years, instead of an alleged target of 10 dB. Without doubt, people would not willingly give up their private motor cars, so it was essential to quieten motor vehicles at source.

The problem of noise in the environment was causing increasing concern to the public; a Mr. Robinson who was a consultant ENT surgeon at the Gloucester Hospital, had approached the environmental health officers of Gloucestershire, requesting a meeting to discuss noise, its monitoring

and its effects on hearing, with a view to an inter-disciplinary exchange of ideas and information. As the Chairman of the Environmental Control Committee of the Gloucestershire branch of the Environmental Health Officers Association, Mr. Howell had been asked to convene the meeting, and invite the attendance of noise specialists from the various disciplines concerned. The principal speaker had been Mr. Robinson, who had stated his concern about the number of his patients who were suffering from noise-induced hearing loss. He had explained that everyone's hearing deteriorated with age, but that the loss could be predicted and that for the average person, with normal age-related hearing loss, a hearing aid would not be necessary until 90 years of age. However, there was considerable variation in individual susceptibility to age-related hearing loss, and there would always be some people who would be handicapped by it. In all cases, however, where noise-induced hearing loss was accumulative with age-related hearing loss, the loss became significant at a much lower age. It had been stressed that noise-induced damage to the inner ear was permanent, and could not be cured, but that it could be prevented.

Mr. Robinson had also stressed that the so-called safety levels were guidelines only, and that they protected only a proportion of the population. Personal susceptibility to noise-induced hearing loss varied tremendously and statistics suggested that an effective safety level would need to be below 70 to 75 dB. The general public appeared to view noise-induced hearing loss as an industrial phenomenon. That was not true, as all noise could potentially cause damage, not only industrial noise. Noisy hobbies and pursuits could lead to noise-induced hearing loss, which would become apparent in later years. Many people who had been exposed to loud noise during the 2nd World War were coming forward for treatment when the addition of normal age loss led to significant overall hearing loss.

A committee called Inter Noise - South West had been set up following that meeting on which the following disciplines had been invited to act: EHOs, Health and Safety represent-

atives, community physicians, the police and industrial representatives. Its terms of reference were:-

1. To educate employers, employees and the general public on the hazards, nuisances, the law and penalties arising from excessive noise in any situation.
2. To encourage complaince with established noise control standards and procedures.
3. To identify problem areas in noise legislation and noise control and to make representations to the proper bodies and authorities.
4. To encourage a multi-disciplinary interchange of information on the noise problem.

Mr. Robson, of Bristol City's Environmental Health Department, and Mr. H. Dawson of Rolls Royce (both NSCA Council members) had been appointed to the committee. Certainly the Society, with its declared interest in noise control, was well represented in the West Country.

PROFESSOR LARGE, replying, said that the Institute had been consulted on that matter and on other matters, and was consulted either through individual membership of committee or, frequently, the Institute was asked to give an opinion as a whole. Personally, he wanted to see specifications in terms of equivalent continuous noise level, but in a three tier way. He thought that there should be some acknowledgment of the average environment, perhaps over a 12 hour period, which could be in terms of Leq. He thought that there should be a restriction on the peak noise level of any single activity which would be in terms of L_{AX}, and he believed that there should also be an acknowledgment in terms of the noisiest hour over which these activities occurred. How those were built into regulations was a matter for debate, but he thought that the relative magnitude of the existing environment should be acknowledged, versus the intrusion that would be imposed on the environment. A very interesting point about induced deafness had been raised, that was worth talking about in terms of environmental noise. Industrial noise deafness was well known, and, in relative terms, well defined. Trying to define whether environmental noise induced deafness was a very difficult, if not an impossible task, the reason being that when hearing loss was examined, there was the effect of

presbycusis, (hearing loss that occurs with ageing) to be considered. That could be discerned, but other loss could arrive through a variety of effects, one of them being health; for example, the instance of otitis media - inflammation of the middle ear - could induce permanent physiological damage to the ear, but it had nothing at all to do with noise. Upper respiratory disease could also induce apparent physiological damage to the ear; again, that had nothing at all to do with noise. Therefore, in order to determine the potential for low levels of environmental noise to induce hearing loss, one had to exclude all those other possible sources of physiological damage. He was not at all sure that, within practical resources, a programme could be mounted to enable that to be done.

MR. C. C. H. FRY (Warwick DC) said that he had recently read with interest the report by Walker and Fields from the ISVR on the community response to railway noise, and had been disappointed not to find a recommended criterion. He had to advise planning authorities on proposed residential developments close to main line railway lines, and like many other authorities, he had adopted the 65 dB(A), 24 hour Leq as a criterion for planning development. He asked Professor Large whether, in the light of recent developments, and particularly the report by Dr. Walker, he agreed that that criterion was still valid, or whether he thought it should be changed to some other value.

PROFESSOR LARGE said that the railway noise survey referred to was perhaps the most comprehensive and scientifically detailed noise survey carried out to date. Therefore, he believed that the data which had arisen from that study was extremely useful and carefully controlled. The reason that no criterion had been recommended was that when the central tendency relationships between annoyance and noise level or activity and noise level were examined, there was no cutting point at which a pattern occurred, where it could be said 'that appears to be the point beyond which you get annoyance or below which you get no annoyance'. Therefore, it was necessary to return to the old process of decision making and decide where that point was going to be for a combination of factors. With a reasonable number of people

satisfied with the environment, having minimised, as far as possible, the number of people highly annoyed, it was also necessary to look at the economic consequences of imposing low noise levels on the railway - provided that they could even be achieved. There was no obvious criterion arising from that study. There were aircraft noise regulations and traffic noise regulations in existence, which were somewhat equivalent. An equivalent railway noise regulation had also to be derived.

COUNCILLOR T. JONES (Manchester Area Council for Clean Air and Noise Control) said that officers had been speaking during the discussion until then, and in many cases, when complaints were made by the public, they came through the elected members of councils. The members were usually involved before the complaints went to the departments concerned. In his experience, it was not the noise level, it was the pitch or the frequency of the noise, and also a new noise, which was disturbing. People might have had noises for many years, but when a new noise was introduced, it was then that complaints were made. A very typical example had been when the National Coal Board at Anderton House, the headquarters of the NCB for the Wigan area, had installed a new computer, which had produced a whining noise and there had very soon been objections from the people living nearby.

On the subject of opencast mining, Cllr. Jones pointed out that the local authority did not receive the planning application; that was made by the Open Cast Executive to the Secretary of State. There had been an example in Wigan of the operation of the NCB 'Juggernaut'. Permission had been sought for the opening of a particular site, and the district council had objected strongly to the proposal. The GMC at Manchester had also objected strongly. A public meeting had been held, which had resulted in a resolution not to allow the development to go ahead as proposed. But the Secretary of State had decided otherwise, and said that the scheme must go through, in spite of public opinion and all the opposing arguments, and the project would be started shortly. Cllr. Jones asked elected members in the audience, with opencast sites in their areas, how many complaints they

had actually had. He said that in the Wigan area there were four in operation, and that before they had opened up there had been a good deal of fuss, but when they had actually started operations, there had been very few complaints because the contractors and the Open Cast Executive had co-operated with a Liaising Committee at each of the four sites. The Committees were made up of local residents, members of the Local Authority, and members from the contracting side, and the committees had been successful in keeping the job going as smoothly as possible.

COUNCILLOR E. N. FLETCHER (Islwyn B.C.) asked whether local authorities were going to be blackmailed by industrialists in the current crisis saying that the cost of putting things right, as required by law, was far too high. He asked whether the NSCA as a whole was going to lower its sights to meet the needs of the economic situation, or whether the Society was still going to press for things to be put right at the beginning, at the planning stage, rather than waiting to cure problems afterwards. He wondered why the U.K. had higher decibel counts than other countries in Europe.

MRS. R. McLUSKY (Women's Gas Federation) asked the speakers whether architects and builders considered noise factors sufficiently when planning new buildings. As a Community Health Council member, she visited, and had done so since it had been built 5 years before, the new Harrogate District Hospital. She had been shown the marvels of a sound-proof room and the expensive equipment which had been installed within it but the staff had mentioned that they had been unable to work for long periods of time within the room due to vibration, which had been at its worst in warm weather. She had enquired whether the room had been simply fitted in, according to demands of space, or whether it had been planned for that particular site. The administrators had informed her that it had been installed on a planned site. Because of her enquiries, the engineers had subsequently discovered the cause of the vibration - a cooling system installed above the sound-proof room, and that had been rectified immediately, fortunately at little cost.

PROFESSOR LARGE reiterated his earlier point about the EEC

versus the Common Law countries, and said that he thought that the problems in reconciling the different approaches would become ever more burdensome as time went on and as regulations became more prolific in the noise field. The vast majority of information available was being used in an incremental sense. The effect of increasing traffic on a highway, or increasing air transportation at a particular airport was examined. However, the evaluation of the impact of an activity in a green field operation was completely deficient. The third London airport was a classical case in that respect. The ISVR had never really been allowed to carry out work which would allow them to examine the impact of the feelings of people towards their environment before the construction took place, during construction of whatever facility was, during the initial phase of operation of that facility, then looking at the steady state situation as to what the community response was once the activity was underway. Such information was urgently needed for planning purposes, for the development of criteria. But it was always the case that sponsoring agencies, whether Government, the Science Research Council, or anyone else, were not willing to take on board programmes of such a long-term nature. It was usually beyond the remit of the lifetime of the officers or politicians involved, and they saw no credit in it for themselves. He urged that the sponsorship of the gathering of information of that type should be investigated, because such information was urgently required.

Turning to Mrs. McLusky's question on architects, he said that he did not wish to be offensive but felt that they had a lot to answer for, certainly in the planning and noise field. Time and time again, the ISVR had found that they were not consulted until it was too late. There were so many noise problems in hospitals, in schools, in apartments, etc. and if only architects had taken advice at the beginning of the programme, rather than at the end, many of the problems could have been solved. Reference had been made previously to Sainsbury's; work patterns were usually totally ignored when a building was being planned, and that was true not only of Sainsbury's, but of Terminal 4 at Heathrow Airport. Not until the building had been erected and the facility had begun to operate had people realised

that a loading bay had been put in the wrong place, when putting it on the other side of the building would have solved a lot of problems. Although architects were becoming more aware, they should still, in some fashion, be forced to take advice right at the beginning of their work.

MR. G. CHARNLEY shared Professor Large's views on architects. He said that guidelines had to be used with great care. Railway noise had been mentioned; Leqs of 65 dB(A) etc. were quoted by the GLC on a 24 hour basis. However, Mr. Charnley wondered whether the research work had catered for the diesel engine standing outside on the main line, waiting for the signal to change at 3 a.m., and chugging away, or whether it catered for the shunting noise near a coal mine where rail wagons went clattering into each other, at sometimes ungodly hours. Guidelines should be used with care, and it should be remembered that they never suited all situations all the time.

B.S. 4142 had been mentioned. He had often heard of notional backgrounds being used, quite often in court cases as well; the attitude being that where no other standard appeared to apply, B.S. 4142 should be used. In a general industrial area with houses scattered in between, it was possible to produce, using 4142, a notional background of some 80 dB(A), which meant that in order to predict a complaint situation, damage to hearing would have been caused (on the basis of a 10 dB difference)! 4142 was also often used, for example, for club noise. He questioned the adequacy of the 5 dB character correction to produce a corrected noise level. It might be far too much, it might equally be far too little; it depended on whether one liked 'Viva Espana'. So far as the use of 'A' weighting and Leq was concerned, the designer could make good use of the 'A' weighting by designing down to the low frequency end, and possibly the use of 'A' weighting would encourage him to do that. Leq was suitable in certain circumstances; he would not regard it as a panacea, but in terms of Leq, it was important to know exactly what that term embodied, what the weaknesses and the strengths of it were. Great care should be taken when using any noise index. Enterprise-free zones had also been mentioned. He hoped that the Government was

not merely paying lip-service to pollution when its members talked about the need to protect society from pollution and health hazards in developments, albeit that those were in enterprise-free zones.

MR. C. R. CRESSWELL, referring to the point about architects and builders said that it was not surprising that they paid so little attention to noise when the minimal teaching of acoustics in schools, even up to 'A' level was considered. The amount taught was abysmal, and until there was advancement in that direction, he did not think that there would be any improvement in the way in which buildings were put up.

With reference to numbers of complaints on noise from open-cast mining, he was not in a position to give actual numbers, but obviously there was not a vast number, as the number of habitants in semi-rural areas was not large. But the proportion of people involved was high; certainly well over 50% of people were bothered.

PROFESSOR LARGE said that he had been very heartened to hear Mr. Cresswell's remark on education; he heartily agreed with it. The ISVR had for many years been trying to get schools to teach more acoustics, one way and another, up to 'A' level. A meeting had been organised for January 1981 with officers of the Noise Advisory Council at which representatives of all the examining boards from England and Wales would be present. The ISVR would be attempting to influence them to change the examination questions, to try and include a greater acoustical content. The teaching of acoustics had diminished remarkably in the previous 100 years. In the old days, physics had been taught in terms of heat, light and sound. Those divisions had all been blurred in modern physics, and acoustics had virtually disappeared. It emerged in some places, in terms of wave motion, but very little acoustics was being taught in schools, not only in the U.K., but elsewhere in the world, and he thought that it was high time that was remedied.

POLLUTION FROM ROAD VEHICLES

The Society's new booklet "Pollution from Road Vehicles" was introduced at the Conference by its principal author, Dr. S. R. Craxford. The discussion on the booklet was then opened by Mr. A. Archer, and questions from the floor were answered by members of the Editorial Committee who helped Dr. Craxford to prepare the booklet.

INTRODUCTION BY DR. S. R. CRAXFORD

The Society's original booklet "Air Pollution from Road Vehicles" was written by Mr. Draper and published in the early 1960s. A second edition, revised by a consultant, was subsequently published in 1967. This edition was running out of print by 1976 and the Technical Committee felt that developments that had occurred since the booklet first appeared were of such a nature as to make a complete re-writing rather than a mere revision necessary and Dr. Craxford was asked to prepare a draft. (In the event the draft chapters on Noise and Conclusions and Recommendations were prepared by Miss Dunmore and Admiral Sharp.) A specialist committee was set up to consider the draft in detail, consisting of Mr. Draper, an automobile engineer, Mr. Boddy, an oil man, Dr. Keddie, a civil servant, Admiral Sharp and Miss Dunmore from the Society, and Dr. Craxford. Sadly, Mr. Draper died suddenly after the writing of the booklet was completed but before it was printed and all concerned joined in dedicating it to his memory in recognition of his very considerable contribution to it as well as to the work of the Society over the years.

The first question that will be asked will have to do with the delay between the inception of the project in 1976 and its completion in 1980. This was not caused by sloth on the part of the authors or the committee but by the fact that the technical members of the committee, from their individual standpoints, fought like cat and dog over almost every sentence, often over every word in a sentence, to the despair of Admiral Sharp and Miss Dunmore. This resulted, however, in a final version that was not a weak compromise solution but was at least an approximation to the truth.

The next set of points to be emphasised concern the basis on which the booklet was written. It was taken as axiomatic that the individual private motor car will remain with us; its convenience is far too valuable to be given up in return for any form of public transport. It is also taken that the internal combustion engine in some form or another, fuelled by petrol or diesel oil, will continue as the source of power for most of these vehicles, at least to the end of the century, by which time a new edition of the booklet will be overdue. The third point concerns the unreliability of forecasts of the motor car population for that period - just as they have been unreliable in the past. It is considered that this does not really matter as the worst pollution occurs in towns with congested traffic where any increase in the numbers of cars using the present streets would be impossible however much the car population of the country as a whole may grow.

In looking at the effects of pollution from motor vehicles and at the steps that can be taken to reduce the concentrations of the pollutants concerned, the fact remains that no deaths or major illnesses brought about by exposure to pollution of the streets by motor exhausts have been reported to us (the activities of EXIT may even have reduced suicides by carbon monoxide in closed garages). The worst effect of this type of pollution is annoyance although it is recognised that there is only a thin and uncertain line between this and mental illness. It follows that the conclusions of the study are bound to be presented in shades of grey and not in black and white.

Finally, coming back, as one does so often, to Lord Asby's principle that complaints come in from the general public, are examined by the experts, and their conclusions sent back to the representatives of that public to decide what it may be politically - in the proper sense of that word - practicable to do: the present booklet, prepared by the experts, comes back now to this Conference, the representatives of at least that section of the public that is aware of air pollution, for discussion and examination.

SESSION 4

POLLUTION FROM ROAD VEHICLES

EDITORIAL PANEL: Dr. S. R. Craxford; Mr. J. H. Boddy, Mobil Oil Co. Ltd; Dr. A. W. C. Keddie, Warren Spring Laboratory; Rear Admiral P. G. Sharp and Miss Jane Dunmore, National Society for Clean Air

MR. A. ARCHER, MBE FEHA (Chairman, Steering Committee on Environmental Lead in Birmingham) opening the discussion, said that care for the quality of the environment had steadily gone up in the scale of priorities and despite the economic situation, both in the UK and abroad, more and more people were expressing concern about pollution whether it was of air, land, water or food.

Protest groups under various banners were being formed and in countries such as Western Germany, France and New Zealand, candidates representing these groups were entering local, regional and national elections. Opinion polls carried out both in North America and Europe had confirmed that improving the environment continued to enjoy strong public support, ranking third, only the fight against inflation and unemployment having a higher priority.

The success story as everyone present knew had been the reduction of 80% in smoke emissions since 1960 and a fall of 50% in average urban concentrations of SO_2 since the early 1960s. As a result, concern which had previously focussed on a limited set of pollutants now included a much wider range and was particularly with the long term effects of relatively low doses of those substances which, it was thought, might give rise to genetic changes, cause cancer or result in neurological damage.

The road vehicles problem was at once complex and one which had become the centre of emotive opinion, not all of which had regard to scientific fact. A serious danger inherent in that situation was that important and far reaching decisions might be made at considerable cost, which might prove to be the wrong decisions. He had been interested to read recently of a comment about diesel engines, as follows:-

"EPA RELUCTANTLY GRANTS SOME DIESELS A TEMPORARY WAIVER OF NITROGEN OXIDE STANDARD

The Environmental Protection Agency granted General Motors, Daimler-Benz and Volvo diesels a two-year delay in meeting the 1981 nitrogen oxide emission standard because with present technology, a reduction of diesel nitrogen oxide emissions is accompanied by increased particulate emissions. The EPA reaffirmed its concern that diesel particulate emissions may be cancer-causing since particulates are very small, tend to lodge deep in the lungs and remain for long periods. The EPA said it would be more protective of public health to minimize the possible increase in particulates while allowing development of more advanced nitrogen oxide control techniques."

Pollution from road vehicles had become so closely associated with the problem of lead in the environment that NSCA booklet was welcome for its attempts to bring the pollution problem into perspective. Annual emissions of carbon monoxide, hydrocarbons and nitrogen oxides, in the order of 7 million, 0.5 million and 0.5 million tons respectively, were substantial. Indeed in the United States it had been precisely because of concern about these pollutants that the Environmental Protection Agency had ordered major gasoline retailers to sell at least one grade of unleaded gasoline from 1st July 1974. To meet the 1975 Federal emission standards, the automobile industry had adopted the use of catalytic converters which would have been rendered inoperative by the use of leaded fuel. The introduction of unleaded fuel had therefore been based solely on engineering considerations and not in any regard for lead as a public health problem.

When comparing the importance of the relative contributions from road traffic and stationary sources, one or two factors needed to be borne in mind. Typically, the impact on air quality of the motor vehicle was aggravated because the emissions were at low level. Often, in areas where there was already an unacceptable level of pollution, the flow of traffic had an important influence on the amount of pollutants emitted. Emissions increased dramatically when, for

example, speeds of moving traffic dropped from say 30 mph to 5 mph. That was a relevant factor when considering traffic management schemes because, where roads were already handling a maximum traffic flow a small increase could lead to breakdown and long delays. Another factor to be taken into consideration and which was often overlooked was the effect of pollutants on the individuals inside a vehicle. Work in Germany had shown that occupants of motor vehicles in conurbations were exposed to CO concentrations of 20 to 50 mg/m^3 every day and that people on holiday and weekend trips, critical population groups such as infants, pregnant women, the old and sick, were at particular risk. Studies in Saarbrücken had shown that after a 30 minute trip, the concentration of hydrocarbon pollutants inside a car would increase to more than twice the peak concentrations recorded on the pavement. TRRL Report 626 Measurements of Particulate Lead at Harlington on the M4 Motorway showed that the driver of a vehicle was found to be exposed to three-quarters of the lead levels found in the motorway atmosphere. The Federal Government of Germany believed that automobile exhaust gases were hazardous to human health, mainly to children, sick and elderly people. Therefore, the Federal Government would consistently continue the programme of reduction of pollutants from motor vehicles. Among the approximately 200 chemical substances in automobile exhaust gases identified to date, hydrocarbons were considered the most hazardous because some of them had been proven to be cancer-causing.

Reference had been made to the rationale for introducing unleaded gasoline in the USA. There was also a second set of regulations in which the EPA had established a 5 year phased reduction schedule which had begun in January 1975 to reduce incrementally the maximum allowable lead content of leaded gasoline to a final average of 0.13 grams per litre. The final stage had not yet been reached because of suspensions arising from anxieties about whether there would be sufficient fuel available. The argument for the phased reduction of lead had been entirely on public health consideration, since EPA considered that present levels of lead exposure from all sources constituted a sufficient risk of adverse physiological effects for a small but significant portion of the adult population and up to 25% of the children

in urban areas. A valid criticism of the booklet was that it failed to point out, in discussing the possible effects of pollution on man, and especially with regard to lead, that particular concern must always be paid to the critical groups in the population. The reduction of pollutants was a complex issue. If the solution pointed to catalytic converters then either base metal converters would need to be developed or lead free petrol would need to be made available. The attitude of the EEC was contained in a written answer dated 18th September 1980 where it was said that: "The Commission considers it important to propose successive reductions in emission limits so as to avoid the need to use catalytic converters of this type (those which required lead free petrol) and to allow time for the development of future improvements. In the Commission's view, efforts to encourage the motor industry and the manufacturers of catalytic converters to work together on the development, at the earliest opportunity, of a catalyser which is both resistant to leaded petrol and effective over a long period would represent a far more rational approach to environmental protection and energy conservation than the untimely introduction of a technology of as yet unproven reliability".

If emission limits could be met without converters, then the problem of low lead versus lead free petrol would need to be resolved. The possible options were discussed in detail in the Department of Transport report 'Lead in Petrol'. The worst possible option in his view was the use of lead filters for new vehicles since their relative effectiveness was poor and their use would pose a serious disposal problem.

In relation both to emission reduction and to noise suppression, Mr. Archer said that the community must be educated to understand that it could have a quieter, cleaner and healthier environment. At the end of the day, however, there was a price to be paid. The radio, television, car and the thousands of other consumer products must all reflect in their final price, the cost of pollution control.

Finally, he thought the booklet might usefully have concluded with an additional paragraph to deal with other motor vehicle generated pollutants - asbestos from brake and clutch linings,

rubber dust from tyres and road dust from the wear and tear on road surfaces. As a last word, he thought it was naive to suggest, as was done on Paper 1, that all pollutants could be blown away harmlessly by the wind.

The Society, Dr. Craxford and the editorial committee were to be commended for gathering together in a compact booklet so much useful information about the problem of pollution from road vehicles.

MR. R. A. SEARLES (Johnson Matthey Chemicals Ltd) commended the National Society for Clean Air on their initiative in publishing the book "Pollution from Road Vehicles", as a contribution to the debate on future emission standards. He also thanked Mr. Archer for his useful introduction to the subject.

Mr. Searles immediately declared an interest, since his company (British) was the manufacturer of platinum catalysts used to control motor vehicle emissions and which were supplied to major US and European Motor Vehicle Manufacturers for the cars sold in the United States and Japan, where stringent emission standards already applied.

He wanted to clear up some common misunderstandings on the costs of tighter emission standards. He did not propose to argue a case for those tighter standards, or for the elimination of lead from petrol, since he was sure that others would be doing that.

It was, he said, generally accepted that the tighter the emissions standards the greater the cost to the consumer. That need not be so. In the US and Japan, the majority of cars sold since 1975 had been fitted with platinum metal catalysts to control pollution and that had required that lead should not be added to petrol in order to boost the octane rating. Consequently, petrol was 92 octane compared to the 98 octane petrol that was commonly available in Europe. To operate a car on lower octane fuel without "pinking" necessitated the use of lower compression ratios which lead to a small drop in the efficiency of the engine. It was commonly accepted by the motor industry that for

every drop of 1 octane rating, there was a 1% efficiency loss, so that lead-free petrol, if no additional refining took place to boost the octane rating, lead to a 6% loss in fuel conversion efficiency.

That, however, had to be put into perspective by a study of the average fuel economy of US cars before and after the introduction of catalysts in 1975. The graph showed that the gradual tightening of emission standards from 1968 - 1974 caused a worsening in fuel consumption as pollution was controlled by engine modifications. The introduction of catalysts allowed the catalyst to do the work of controlling pollution so that engines could be tuned for best economy.

In Europe, figures from 6 - 20% were commonly quoted as the cost of going to lead-free petrol. That would be true if 50% of pollution from motor cars were not already controlled by engine modifications. If catalysts were fitted to European cars, it would then be possible to retune the cars for economy rather than pollution control and some, if not all, of that 6% fuel economy loss could be regained.

It was argued by oil and motor companies that to stop adding lead to petrol would adversely affect fuel economy, because of the need for lower octane ratings. However, most German and Japanese cars were designed to run on 2-star low octane fuel as used in US and Japan. He suggested that those cars were not noted for being thirsty. Many other factors were important to fuel economy.

Catalysts, as used in the US and Japan, usually took the form of a ceramic honeycomb coated with a small quantity of platinum (typically 2 grammes per car), through which exhaust gases were passed. The honeycomb was mounted in a stainless steel "can" rather like a small silencer, which it often replaced, and mounted close to the engine. In its simplest form, when used to oxidise carbon monoxide and hydrocarbons, air provided the necessary oxygen and was pumped in. Catalyst manufacturers, including his own company, were working on the development of catalysts that were tolerant of lead for use in the European market. He wanted to correct a point made by Mr. Archer, who had referred to the need to

develop base metal catalysts. Catalyst companies had looked at both base and precious metal catalysts, and it had been found that the most promising results obtained had been with precious metal catalysts using leaded fuels. That work was continuing and encouraging results were being obtained.

Finally, mention had been made of the diesel engine, so he wanted to discuss an application for those catalysts that was being used by British Industry. The unpleasant odour of diesel engine and carbon monoxide and hydrocarbons could be eliminated by simply fitting the Honeycat® diesel exhaust purifier into the exhaust system. Such catalysts were being fitted to diesel engines in forklift trucks, sideloaders, cranes, generators and mine locomotives; in fact, anywhere where people worked in confined areas with a diesel engine.

Mr. Archer had made reference to the control of particulates from diesel engines, and Mr. Searles confirmed that in US severe regulations would be introduced in two years' time, that would require some treatment of diesel exhaust to remove particulates. Encouraging results had been obtained with new catalyst systems that oxidised the hazardous hydrocarbons adsorbed on to the particulate.

In conclusion, he supported Mr. Archer's suggestion of collaboration between the interested parties of the Government and Industry, (Motor, Petroleum and Catalyst Manufacturers) in order to find solutions to enable pollution control to be obtained without sacrificing fuel economy. Indeed, his own company was currently working on a programme with the motor industry, partially funded by the British Government, to develop lead tolerant catalysts for the European market.

<u>MR. H. NOWELL</u> (Bath City Council) said that although it had been mentioned that afternoon, he wanted to return to the subject of vehicle noise emission. He believed that there was in existence an EEC draft directive to increase maximum lorry weights. The increase in engine power required to cope with the increased weight might well result in increased noise levels and ground vibration. He asked the panel to comment on whether that was a fair interpretation of the

likely outcome and whether the research of TRRL on the Quiet Heavy Vehicle could or would be utilised to offset such deleterious effects. Finally he asked whether the panel agreed with the Department of Transport assertion that the major source of vibration was low frequency sound from exhaust, and that it was exhaust design and not vehicle size that was the problem; if the panel did agree, he asked whether the public would also be convinced by DOT's argument.

MR. J. H. BODDY said that the question was rather detailed and technical. The EEC legislation permitting larger vehicles was going to influence the sort of noise that would be obtained from vehicles; the suggestion that vehicle noise was largely generated from the exhaust was slightly erroneous; there was a considerable amount of noise from the injectors and from the combustion side, and obviously, the larger the engine, the greater the noise, except in so far as turbochargers could be used in diesel engines. That was a design feature of many of the European engine designs, by which lower noise levels could be achieved with larger engines and possibly larger vehicles. His personal feeling was that larger vehicles did have an undesirable feature in so far as the vehicle itself generated noise apart from the engine. So the question of noise from a vehicle was not one which can be isolated to this or that component, it was very complex indeed, and there was a long way to go in overcoming the problems. He hoped that some of the development work carried out by Rolls Royce in that area would help to overcome the problems and give improvements for future vehicles.

MR. P. JONES (Leeds City Council) asked about the future possibility of heavy lorry bans. The 1980 Government White Paper on Strategy for Roads had put back some of the road by-pass plans; in his own area, a scheme that had been going ahead in 1981/2 had been put back to the reserve list for 1984. At the same time, the British motor manufacturers, being in a difficult financial position, would have fewer resources to proceed with resolving pollution and noise problems with vehicles; and county councils seemed to have fewer funds for road repairs. He wondered if the panel could explain, in those circumstances, what impact they hoped to have on the operation of future heavy lorry bans,

both from city centres and the redirection of lorries on to motorways rather than on existing roads.

DR. A. W. C. KEDDIE said that if there was a reduction in the number of heavy lorries going through city centres, then it would make a contribution to the reduction of emissions of particulates, oxides of nitrogen, etc., in city centres which would have some local beneficial influence on air quality. However, he suspected that the question was more concerned with noise and damage to road surfaces and he was not really in a position to answer on those particular points.

MR. H. I. FULLER (Chairman) said basically the question concerned Ministry of Transport and local authority responsibilities. A great deal of work and thought had already been given to the redirection of traffic to control pollution.

MR. K. TEESDALE (Ford Motor Co. Ltd.) congratulated the Society, the authors and the editing committee for the production of the new edition of the book on such an important topic. He commended the booklet for its balance (a word which had taken a battering the previous day), which was one of the aspects which seemed to have come through very well, and to be very important in what, as had been mentioned several times, could be a very emotive subject. However much the Society wished to ensure that its crusading zeal was kept nicely polished, he thought that balanced objectivity and facts were things that had to be kept in mind on a subject which, in the case of most vehicles, had to be regarded as a consumer durable. Therefore, to use another rather hacked about word, an effective compromise was required. His own company made a product which was also an international product. In the majority of consumer products that international aspect introduced further compromises. Therefore clearly, in addressing what was technically possible on any one particular pollutant or any particular disbenefit of such products as motor vehicles, it was essential not to fall into the hole of devaluing the compromise in something which had to be, in a way, all things to all men, as far as motor vehicles were concerned.

The question of noise had been raised, with several questions on the need to revise certain British standards and international standards in respect of the measurement of noise and noise criteria. That applied equally to the motor vehicle. Motor manufacturers used a noise test method which had been around a long time. There had been quite severe proposals and his company were about to reply to a Consultative Document put out by the Department of Transport on the cost of meeting those more severe noise levels, based on the original test method. The EEC had seen fit to publish its proposals to its member states; however, it had proposed a revised noist test method, one which his company would welcome as it was more technically sound. But when companies were required to swap horses in mid-stream like that, it did throw into confusion all the hard work that had had to be done. To go through the entire model range and figure out what it was going to cost to put everything right, to a certain arbitrary (as all such methods were) test method, only to be confronted with another, albeit better one, was a significant factor which had to be borne in mind.

The question of whether the EEC proposals on heavy vehicles, juggernauts etc. would lead to more noise or damage had been raised. Again Mr. Teesdale thought that the subject had been treated very emotively. He thought that the motor industry, operators, TRRL and the Government had shown, fairly consistently over the previous five or ten years, that they and many other of the revered institutions in Britain and elsewhere were agreed that going from thirty two tons (the current maximum level for Britain) to a figure more comparable with the other Common Market countries, something around the order of forty tons, was generally speaking going to be an improvement. The design would normally bring in another axle which would reduce axle load. He himself was not a civil engineer, so did not want to go too much into the relation between axle load, wheel load, bridge loading, the fourth power law, the thumping in pot holes in the ill maintained roads, for the repair of which there were insufficient local authority grants. However, he thought that there was a pretty sound case to be made out that, provided the thirteen ton axle beloved of some of his continental colleagues was avoided, the EEC proposals ought

in general to result in a given tonnage being moved by fewer vehicles more quietly and more efficiently, both from an auditory point of view and a road maintenance point of view.

MR. BODDY thanked Mr. Teesdale for a very good explanation of the heavy vehicles situation. Mr. Boddy had suggested that he was a little bit against the larger vehicles on the basis of noise and that roads in the UK could not take them easily; however, at the same time there were advantages in reducing, not only the number of vehicles but also in the level of emissions of pollutants which might result from a smaller number of larger vehicles. It was a very difficult decision to take and he thought it was one that the Society might debate at some length.

Going back to some of the points raised earlier by Mr. Searles, Mr. Boddy felt that he had given an excellent dissertation on catalytic converters and their application and he agreed that if they had to be used, if more rigid standards of emission control were necessary, then obviously those sorts of devices were useful and could probably give the best answer to the problems. It was this 'if', that really needed to be considered. The booklet had given a fairly good outline of what the problems were. The problems of hydrocarbons and NO_x were not really problems people needed to worry about too severely in the UK because the country did not get the smogs which had been the basic cause of the requirement for NO_x and hydrocarbon control in the United States. The country had a problem with carbon monoxide; it was undesirable for this to worsen. We did not want it to poison the pedestrians on the streets. On the other hand, it should be recognised that many were probably doing far more harm to themselves by smoking cigarettes than by breathing the air which was over the pavement.

The real need was to look at the priorities. The immediate priority in the UK was to improve the economy. If a lot of money was going to be spent, which would perhaps increase the cost of a car by two or three hundred pounds or more (perhaps that did not sound an awful lot in terms of current car prices, but it was a significant increase), and the price of fuel was going to be increased in order to reduce

the lead content, because in order to produce the same quality of fuel without lead the cost of producing petroleum would have to be increased, we would not get the economy right. Those were the factors which had to be considered by the population of the country. People had to ask themselves whether it was really worthwhile, and what they really wanted. It was a question of balance; balance in maintaining economic stability, and at the same time preserving the amenities which people wanted and which were useful. In that respect, he recommended delegates to read through the book and ask themselves whether it was really necessary to do very much more than was already being done.

Should the point be reached where the economy had recovered and the population started buying more and more motor cars and there was more and more congestion on the roads, then obviously further thought might have to be given to controlling pollution from motor vehicles. Consideration might have to be given to the use of catalysts, as Mr. Searles had suggested. There were so many pollutants that could be considered, and rather than saying, "Well, here is a pollutant; let's get rid of it", it was important to get the priorities right and consider which were significant and should be tackled first. In his view, road vehicle pollution was not a serious problem at the present time, and it was not one which required too much action to correct. Noise was another matter. He had been very impressed by the discussion on noise at the morning's session, with consideration of domestic noise and the problems of airports etc., which were the difficult problems to solve, and those should be given major priority.

REAR ADMIRAL P. G. SHARP said that the Society had always advocated that everything should be done which could reasonably be done, and he stressed the word reasonably, to reduce the emission of pollutants from motor cars. So far, until it had been shown to be absolutely necessary, it had steadfastly set its face against what it had called 'hang on devices'. In other words, the use of catalytic converters in motor cars, unless it could be shown that they were absolutely necessary. He thought that what had been said in the booklet summed it up. "The existing and proposed EEC

regulations appear to be sufficient to provide control for petrol engined vehicles used in this country and Europe. The extent of these proposals will not, at the present, necessitate the use of catalytic converters in Europe. These will, however, have to be used on cars exported to the USA to comply with their regulations aimed at controlling photochemical smog. Nevertheless, if it is subsequently shown that hydrocarbons, or the oxides of nitrogen, pose a problem in Europe and the UK, it may be necessary to fit catalytic converters."

The EEC were currently considering whether they needed to go further. They were advancing and tightening up the regulations each year that passed, and if they decided that further control over hydrocarbons and more particularly, oxides of nitrogen, was required, then it might well be necessary to fit catalytic converters.

So far as noise was concerned, to a degree, the same thing applied. The EEC regulations were increasing in intensity, albeit perhaps, not so quickly as some would like to see. The panel were agreed that noise from motor vehicles was almost more of a nuisance, more annoying, and more frustrating than the chemical pollutants emitted from the exhaust pipe. Certain recommendations had been made about noise. It was felt by the Society that more should be done in that respect, and the recommendations had been set out in chapter 10 of the booklet.

MR. BEAGLE (London Borough of Hammersmith & Fulham) said he had been interested in Mr. Boddy's observations on the necessity or otherwise for the control of pollutants, i.e. lead, other chemicals and the various products of combustion. It had struck him that while people in the UK were bitterly complaining that the numbers of foreign cars being sold in the country had reached levels unacceptable to the UK motor industry, the Japanese had agreed to reduce imports from thirteen to eleven per cent. He wondered whether there was a case for the Britich car manufacturers to try and meet Japanese motor vehicle pollution emission standards so that the British car exports to Japan could be eleven or thirteen per cent, so the boot could be on the other foot. He thought

that was just as important as considering whether or not the UK needed to meet such pollution emission standards, and that people in the UK were being a little bit complacent about it.

MR. M. E. PADDOCK (Birmingham City Council) commented in the light of the Lawther Report. That report had divided blood lead levels into three groups: greater than 80 μg/dl, where there was evidence of clinical lead poisoning, less than 35, where they said that there was no definitive evidence, and the grey area between 35 and 80. The middle group had been examined in Birmingham, in connection with the work of the Steering Committee, of which Mr. Archer was the Chairman, and at the moment they could find no evidence to suggest that lead in air was a major contributor. Looking at the median blood lead levels in the under fives in the city (with levels in the order of 16 to 20 μg/dl), then it was surely a more significant factor.

Work at Harwell had suggested that a lead in air level of 2 $\mu g/m^3$ could result in a blood lead level in the order of 6 μg/dl. Certainly there had to be situation where lead in air concentrations exceeded that figure of 2 $\mu g/m^3$; in Birmingham in heavy traffic areas there were peak levels in the order of 8 or 10 $\mu g/m^3$, and those peak levels were not uncommon. One among the many recommendations of the Lawther Report was that where the annual mean concentration of lead in air exceeded 2 $\mu g/m^3$, which was also the current EEC guideline, then steps should be taken either to remove the source or the recipients. He thought that that level was certainly exceeded in many situations in urban areas.

Looking at the control of other pollutants, he said that if control was to be achieved by catalytic conversion then lead-free petrol would be required. It was generally accepted that, even if action were to be taken at once to remove lead from petrol, there would still be leaded petrol available for some considerable time. Since it was likely to be cheaper than lead-free petrol, it was his view that as long as the choice was available then people would use the cheaper fuel irrespective of whether or not the vehicle had been fitted with a catalytic converter. Therefore there

seemed to be little point in pursuing the control of other pollutants by catalytic conversion until such time as a decision had been made to remove lead from petrol. He did not wish to appear emotive, but he thought that there was an element of doubt as to the effect of lead from petrol on blood lead. One thing was certain, that if the discussion on the subject continued in the same way, it was likely that the resources of fuel would be exhausted before any decision had been made.

MR. ARCHER said that it was a difficult question to answer because there were so many variables involved. What Mr. Paddock was saying, as he himself had mentioned earlier, was that it was necessary to look at the critical groups in the community; one of the critical groups, of course, was the pre-school child. In Birmingham there were blood lead levels of something in the order of 20 μg/dl of blood in pre-school children, as against perhaps only 14-15 in shool-children. That led on to the problem of lead in air and lead in dust. What Dr. Chamberlain had shown, which had been accepted in the States, was something like a two to one ratio. That was probably reasonably valid, but the problem was not solely one of lead in air. If, for example, something like twelve thousand tons of lead were put into petrol annually, something like nine or ten thousand tons of particulate matter would be distributed in the community. That was why he had questioned the comment 'It is all blown harmlessly away'. He did not think that was correct, and said that the areas of uncertainty were the proportion of lead in blood which was related to inspiration, the proportion picked up from lead in dust, and how much of that lead in dust came from petrol and how much came from other sources. It was known that some children had relatively high blood lead levels in the pre-school group, and there was growing evidence that those sorts of levels might have some effect on the neurological development of the child. That was part of the work, as Mike Paddock had said, being done in Birmingham, which Mr. Paddock was very much involved in and, indeed, in charge of. But the answers were not yet clear.

DR. S. RUTTLE (Department of Health and Social Security) said that his remarks expressed personal, rather than

official, views. He said that although there were areas of uncertainty, there was no real reason to be anxious about small amounts of lead. The communities that had had small amounts of lead were not known to have contributed anything to civilisation. He was taking them in terms of blood concentrations below 15 $\mu g/m^3$ or so. Once figures of around 35 $\mu g/dl$ of lead in blood were reached then it approached the area where it was known that enzyme deficiency might begin to have an effect. The enzyme activities could be measured but a necessity for all of them had never been demonstrated. There were a great many enzymes in the body, which could be numbered in thousands and while the reasons for them were not known, they obviously were not there for pleasure. The question had to remain open. There was some evidence that lead was important in the metabolism of iron so that it was a bit premature to say that lead was completely unnecessary. There was some evidence that it might be, but it was very early days to say anything more definitely than that. It was a matter of ordinary clinical priorities; 35 $\mu g/dl$ was an upper limit. The more it could be reduced, the better, but he could not ever see it being reduced to nil. The main problem was to find the so-called 'hot spots', where children were exposed to lead from paint, or food, and might have different metabolism such as in some groups of immigrants, who were getting relatively large amounts of lead from air in 'hot spots' in various parts of urban Great Britain.

<u>COUNCILLOR DENIS LOVELACE</u> (Bath City Council) said that when he was a lad, his grandmother had used to tease him by saying, 'What noise annoys an oyster most?' When he had gazed up at her, she would reply, 'A noisy noise annoys an oyster most'. After she had played that trick on him a few times he had developed the courage to say to her one day, 'Granny, what <u>is</u> a noisy noise?' Her wisdom had flattened him as she had replied, 'Well that, my lad, depends upon the oyster'. The discussion there had been over the preceding couple of days about noise had made him feel very much like an oyster. He lived within twelve feet of what must be one of the least scenic attractions of the fair city of Bath, namely the A36, which ran through the ward he represented and which also took traffic diverted from the A4. The A36 carried the traffic from Southampton to Bristol and the A4

carried the traffic from Bristol to London.

He wanted to take issue with some of the statements which had been made regarding the need for bigger lorries. It was a fallacy. The road haulage lobby and the lorry manufacturers' lobby in the UK were simply interested and concerned only with building bigger and better lorries which would go faster from one place to another. Their advertisements in the press declaimed their advantages: how comfortable they were for the driver, how much extra profit hauliers could make with them, how much their payload was increased by putting an extra axle on; but he had yet to see one single advertisement advocating bigger lorries which said that they would be safer for the pedestrians they knocked down, or quieter for the residents as they passed their gardens in the middle of the night.

He thought that bigger lorries should be challenged, over and over again, because the lobby which ought to be heard in the UK was not the road haulage lobby or the vehicle manufacturers' lobby but the residents' lobby - those who suffered from the noise and saw no relief from it. Even in the booklet, the Society had to admit that the police were not doing their job of prosecuting when there was cause for prosecution. And it was because the law was unenforceable, as were so many byelaws.

One of the things in Bath, and which again was not a tourist attraction, was an empty container lorry. Regularly, every night of the week, at three o'clock in the morning, it bumped its way from pothole to pothole along the road from Bristol to wherever it happened to be going. It woke up every single person who lived on its route. He wondered what could be done about it. He had thought of going out in his pyjamas to frighten the driver in the middle of the night, get him to stop and to take his number, but the driver was not committing any legal nuisance, and he was not breaking any law by banging along in his empty container lorry. He asked the panel whether it was not simply a question of filling up the potholes (which Mr. Hesseltine had told the county council it could not do, because otherwise it would dig itself into another hole) but rather per-

haps a question of saying that an empty container lorry should go at a slower speed in the middle of the night than one which was laden. Obviously it was the difference between the load and the non-load which caused it to bounce. He did not believe for one moment that any motor manufacturer would design a lorry which would bounce less when it was empty.

He believed that the important thing was to look at the question of enforcement. He had argued at the 1978 Brighton Conference that so many regulations, and byelaws, so many of the things which councillors and officers tried to do, faltered and foundered upon that one fact, that the police could not be persuaded to act. The reason for the lack of prosecutions by the police had been mentioned more than once during the 1980 Conference. It was because it took them so long to prepare a case, to secure the evidence and to go along to the magistrates and repeat it, and have it all written down in longhand by the clerk of the court. It took so long that at the end of the day the five, ten or fifteen pounds' fine imposed was just not worth the candle. He thought that the Society should be looking, not only at the causes and the remedies, but at how those remedies could be applied. He suggested once again that the Society should advocate the introduction of spot fines for people, on the spot where the offence was committed, giving people the opportunity, if they disagreed with the verdict of the policeman who said they were breaking the law or a regulation, of then going to the magistrate's court and challenging his evidence there. Until the impasse, of the police not being able to enforce rules and regulations, could be overcome, all the work which as a Society, and as officers, members of the audience did, that he himself might do as a councillor, would come to absolutely nothing. He saw his own house vibrating every day, and he did not believe that smaller lorries or bigger lorries were going to make any difference. The noise was there, the problem was there. People had to realise that to put heavy and noisy lorries on the road was an uneconomic proposition.

MISS J. DUNMORE supported much of what Mr. Lovelace had said. She lived on a very busy, narrow road, which carried

a lot of heavy lorry traffic. She did not think that bigger lorries would be able to negotiate the bend just before her own house; she also knew all about thumping and rattling sounds at night, and was frequently woken up by them herself. Her personal view was that more freight should be switched from road to rail transport.

<u>REAR ADMIRAL P. G. SHARP</u> said that he lived a respectable and decent distance along the same road as Miss Dunmore, and suffered in the same way. Of course, the suggestion to restrict the speed of lorries at night etc. was again a matter of enforcement. He then chucked a brick into the pool by asking whether local authorities could themselves undertake the business of controlling traffic noise. The police found it difficult, and considered that the law as it stood was too cumbersome. He believed that drastic action, such as the immediate banning of noisy motor bikes until the they were effectively silenced was necessary - and what was being done would soon get around and have an effect. But the police were not going to do it. He wondered whether local authorities could do it, whether there were enough environmental health officers tc go round to say definitely that a particular person was making too much noise. The general public all knew when a motorbike, for example, was making too much noise; everyone winced. But at present the offending bike had to be taken away to a quiet field, some miles away, where the background noise was acceptable, and the noise from the bike measured. That was ridiculous, and the police could not do it. He believed that a change in the law was needed and it had to be some form of much more rapid, if rougher, justice. That might achieve the desired results. But whether the local authorities were in a position to do it, he did not know. There were many local authority representatives present who could say whether they could cope.

<u>DR. S. R. CRAXFORD</u> said that the important thing to have emerged from the conference, was nothing to do with air pollution or indeed with the booklet in general; it was the general question of noise, that what annoyed one person did not annoy another. Every paper on noise presented at the conference had highlighted this point. What was required was

not a widening of the powers of local authorities, it was a new law dealing with noise that would take the subjective nature of noise into account. It was no good dozens of people saying that a particular noise was not a nuisance to them, when there might be a dozen across the way, scattered equally among the community, who would say that it was. It was no use simply measuring decibels. A radical change at the very top in the legal structure dealing with noise was needed.

MR. R. A. SEARLES (Johnson Matthey Chemicals Ltd.) said that during earlier discussion and questions, reference had been made to the problems in having both lead-free fuel and leaded fuel available at the same time, and the probability that motorists would go for the cheaper, leaded fuel. In the US and Japan, that had been made difficult by using special filler nozzles, so that it was impossible accidentally to fuel a catalyst-equipped car with leaded petrol. In the US there was an incentive for motorists to cheat, since leaded fuel cost a few cents less than unleaded fuel. In Japan, however, using a differential taxation, that incentive was removed, since unleaded fuel cost less.

Admiral Sharp had referred to the National Society being opposed to the use of 'hang-on' devices. Mr. Searles respectfully suggested that the catalytic convertor was fully accepted by the motor industry as an integral part of their engine system, and while in the early days it had been regarded as such, or as a black box, the use of the device was now fully understood and welcomed by the motor industry, since it enabled them to concentrate on designing engines for performance and economy, and not emission control.

He supported the comments on the need for British manufacturers to sell more cars in Japan. While it was made difficult for imported cars to meet Japanese regulations there were no technical barriers to that, since cars that met US California Emission Standards would also pass the Japanese test.

MR. C. WHITE (London Borough of Hackney) said that he was somewhat confused. Mr. Searles had said that Japanese cars

made a big point of their economy. Yet Mr. Boddy had told the audience that there was in fact a fuel penalty attached to taking lead out of petrol, generally put at around 10%. Those two statements seemed to him somewhat inconsistent. He tended to believe that there were better reasons for taking lead out of petrol than there were for putting it in. However, the fuel penalty reason, put forward by the oil companies, tended to convince him that lead ought to be put into petrol; since there did appear to be inconsistencies, he asked whether he could have some enlightenment on the point.

MR. H. I. FULLER (Chairman of Session) said that the paradox was more apparent than real. It depended upon which part of the economy of the system was being examined. The oil industry started with a barrel of crude oil and considered making petrol from it and then worked out how many miles a car could be persuaded to run on a gallon of petrol. That was where the figure of 10% came in. He rather thought that the other calculation had been based on taking a gallon of petrol and seeing what difference it made to the mileage of the car. The oil industries considered that the more significant factor was the cost to the country in crude oil resources. Mr. Fuller then asked Dr. Keddie to make a wider response to several of the questions that had been asked during the session.

DR. KEDDIE said that he first wanted to put the record straight slightly. He had been introduced by Dr. Craxford earlier as representing officialdom. That was true to the extent that he worked in a government laboratory, but the laboratory (Warren Spring) worked for a variety of government departments, local authorities and industry. He therefore represented a neutral position rather than a particular policy line; his remarks should be seen in that context.

He was afraid that he would disappoint those who had a professional interest in noise as the subject was outside his remit; he obviously had a considerable personal interest in noise but professionally, had no credible views!

On vehicles and air pollution he had several points to make.

The first was that it was important to distinguish between the two classes of pollutants of which motor vehicles were a source. There were primary pollutants: those which were found in the atmosphere in the same chemical and physical form as when emitted from the exhaust, carbon monoxide, smoke, lead, nitric oxide, and possibly hydrocarbons. The major impact of motor vehicles in so far as those pollutants were concerned was generally at the local scale, at the kerb-side or very near to the kerbside. Moving on to secondary pollutants, i.e. those pollutants which were produced from the primary pollutants by chemical reactions in the atmosphere, those were generally much more uniformly distributed whether in urban areas or throughout the environment generally. The two typical examples were ozone and nitrogen dioxide, which was produced from the oxidation of nitric oxide. In that case, hydrocarbons, especially the reactive hydrocarbons, had a fairly major role to play. It saddened him to some extent that motor vehicles were frequently identified as the modern "villain of the piece" without due respect for the evidence. In the case of pollutants such as NO_2 and ozone, at the present time the contribution from motor vehicles was simply not known with any degree of certainty. The Society's booklet showed that motor vehicles were not the major source, in emission terms, of oxides of nitrogen and of hydrocarbons. Stationary combustion sources, i.e. boiler plants for NO_x and evaporative losses of hydrocarbons from petrochemical plants and solvents, were estimated to be more important. Furthermore, evaporative losses probably played a major part in the production of secondary pollutants because they were a major source of the reactive hydrocarbons which were an essential element of the chemical reaction chain.

Returning to Mr. Archer's comments, Dr. Keddie thought that one of his points had been that West Germany queried the UK concern about lead while the UK was apparently not so concerned about oxides of nitrogen and hydrocarbons as were the West Germans. That point was worth exploring a little further. The United Nations' Economic Commission for Europe was the organisation within which the regulations on motor vehicle emissions were essentially agreed. Those were eventually taken up by the European Community and became

legislation in the member countries. In the latest review of the series of amendments to Regulation 15, as it was called, the West Germans and the Swiss had pushed very strongly for much more stringent emission limitations on carbon monoxide, hydrocarbons and oxides of nitrogen than had been ultimately agreed. One important reason for their failure had been that their arguments, asserting the importance of motor vehicles as a source of ambient concentrations, could not be sustained against UK counterarguments to the effect that the evidence presented had been at best very inconclusive. Nevertheless, West Germany appeared to be continuing a strong campaign for a reduction in motor vehicle emissions while at the same time expressing reservations over the need for an air quality standard for NO_2.

Dr. Keddie said that he would agree with their doubts about the need for an NO_2 standard, but the West German stance did not appear to him to be self-consistent. It might be that the imposition of an air quality standard on stationary sources would pose considerable technical and economic difficulties for West Germany while the motor vehicle emissions would be comparatively easy for them to control. That was simply one possible interpretation, but if true it did mean that there could be a motor vehicle trading advantage to West Germany in seeking strict exhaust emission controls on the grounds (as yet unproven) that motor vehicles was a major source of, say, ambient concentrations of NO_2. Dr. Keddie had expanded on that example, not because he believed that NO_x and hydrocarbons should be dismissed as a non-problem, but because it was important to examine carefully the evidence and motivation behind many of the statements and proposals which emerged.

Dr. Keddie also wanted to say something on lead although he did not want to dwell on it over long as the Society had had a special meeting to discuss lead after the publication of the Lawther Report. Firstly, it was important to bear in mind that there was very little or no clear relationship between air lead and blood lead when studies of the general population had been carried out, a point that had emerged that afternoon. He also thought that it tended to be forgotten that the annual average lead levels in the general urban atmosphere were about 1 $\mu g/m^3$ or less. If

Dr. Chamberlain's conversion factor to blood lead was accepted, then that would lead to about a 2 $\mu g/dl$ equivalent. There were, as Dr. Ruttle had pointed out, hot spots which might have significantly higher concentrations, of 2-4 $\mu g/m^3$ at the kerbside of busy streets. That raised the question of what proportion of the population it was desirable to protect. All he would say was that if it was thought desirable to get below the 2 $\mu g/m^3$ guideline, which had been suggested within the Lawther Report and was currently being proposed by the European Commission, in all areas, it might be necessary to reduce the lead in petrol to below 0.15 g/litre. That would have important implications. The other aspect of the lead story was of course lead in dust, which several people had referred to. There was little doubt that lead from motor vehicles did contribute to the lead in dust but Dr. Keddie said that it should be borne in mind that much higher dust lead levels (about ten times) were found in the vicinity of leadworks and scrap merchants, etc., than were found in the vicinity of roads.

MR. J. H. BODDY, in a written contribution, took up the point made by Mr. White and in part by Mr. Beagle on the necessity for lead in petrol in order to improve fuel economy. In itself, lead did not directly affect the efficiency of the engines. It was only by allowing the use of high compression ratios because of the increased anti-knock quality that more efficient engines could be designed. The fact that some Japanese cars could operate on lead-free low octane petrol and were no more thirsty than European cars did not detract from the point that those same Japanese engines modified to take advantage of 98 O.N. petrol could achieve some 6% or more in fuel economy. In summary, the petrols which were reduced in Octane Number by the elimination of lead additive had reduced potential for vehicle fuel economy. There was an alternative route to increase the Octane Number of petrol by additional refining processes. However, those processes could involve more energy use in the refining process than would be saved in better economy of the vehicle. For those who wish to study that point in more depth, he commended a publication issued by CONCAWE in 1980, Report No. 8/80. Alternatively, a slightly older paper, essentially based on the same data, had been published in

the proceedings of the Institute of Petroleum Annual Conference in 1978 under the title "The Overall Economy of Engines".

To make a very broad generalisation on a quite complex subject which related to Mr. Searles' comments on fuel economy, it could be estimated that a change from 0.4 g/litre of lead to zero lead in petrol would result in more than a 5% increase in crude oil requirements to satisfy automotive demand. If the energy penalty was not achieved by matching the fuel octane quality and engine compression, greater loss would occur.

On the question of concern about lead concentration in air, it was perhaps appropriate to explain that the first phase of Dr. Chamberlain's work on the effects of vehicle emissions of lead on blood lead level had produced the conclusion that 1 $\mu g/m^3$ of lead in air produced an increase of 1 $\mu g/100$ cl of lead in the blood. Subsequent work and the influence of other published work had led Dr. Chamberlain to revise that conclusion to say that 1 $\mu g/m^3$ of lead in air would produce an increase of 2 ug/100 cl of lead in the blood. Mr. Paddock, in his contribution to the discussion, had stretched that figure to 3. Fairly careful reading of Dr. Chamberlain's final report had not convinced Mr. Boddy that he had been justified in changing his conclusion if he had considered only his own results which Mr. Boddy believed had been carried out carefully and perhaps with better accuracy than others which had helped to persuade Dr. Chamberlain to change his conclusion. With those considerations in mind, he was loathe to accept Mr. Paddock's even higher figure.

SESSION 5

SMOKE CONTROL

THE EC DIRECTIVE ON SMOKE AND SULPHUR DIOXIDE: THE FUTURE FOR SMOKE CONTROL

Mr. Paul Evans, Department of the Environment

POLLUTION AND THE COMMUNITY

Mr. Frank Haynes, MP

MR. D. LOVELL, opening the discussion, said that in March he had been approached by a young man at an NSCA divisional meeting, who had asked him if he were going to the Clean Air Conference. He had replied that his local authority restricted officers to two conferences a year, and the NSCA Conference was not on the list. The young man had reminded him that it was being held on his own doorstep at Bournemouth and he had begun to see faint possibilities. Without further hesitation, he had said that he was looking for someone to open the discussion following the presentation of two papers, and Mr. Lovell was the very man to do it. Mr. Lovell said he had studied the conference programmes for the past five or six years and had wished to attend some, if not all, of the sessions, but because of financial constraints, common to all, had not been able to do so. He was therefore delighted to have the opportunity at last of attending one of the excellent NSCA conferences, if only by somewhat devious means.

He complimented the organisers of the session in establishing the correct order of precedence of speakers; namely, civil servant, politician, local government officer - if the programme 'Yes, Minister' was anything to go by. He congratulated both speakers on the excellent content of their papers, saying that they had provided much food for thought and would stimulate a lot of discussion. The one thing he had learnt about Frank Haynes was to watch for the unexpected. Before the session had begun, Mr. Lovell had told Mr. Haynes that he hoped he would stick to his written paper, because Mr. Lovell had based his remarks on it. With a twinkle in his eye, Mr. Haynes had said 'Oh yes, certainly, but I've got a message to put across'. And he certainly had

put it across.

Mr. Lovell said that despite living and working in the relatively unpolluted air of Dorset, he and his colleagues were aware of their environmental responsibilities. Poole had been part of the National Survey of Air Pollution for many years. Despite its industrial and residential growth, which had been considerable, levels of pollution had fallen quite steadily as a result of voluntary moves from the use of bituminous coal to the various types of smokeless fuels. The Authority had decided that whilst that situation continued, it was not necessary to indulge in a programme of smoke control. The administrative costs were not justified by the small benefit that might be gained. That brought him to a comment on Paul Evans' paper on the EC Directive. While he could see certain merit in establishing limit values and guide values for sulphur dioxide and suspended particulates in the atmosphere, he did hope that Brussels would not become preoccupied with the numbers game. Local government was still local; and district councils ought to know their local conditions best, and what their environmental priorities were. Clearly, as Frank Haynes had said, there was absolutely no excuse for inactivity where pollution levels were really bad. But he did not want to see the initiative taken away from local government and directions given by Brussels, or even by UK central government, simply to satisfy what were empirical values. Member states of the Community had their own customs and methods of working; he believed in flexibility and that it was preferable to any rigid system. Even local authorities currently enjoying low levels of pollution ought to continue to improve the situation and not just wait until certain values were exceeded.

Turning to Frank Haynes' written paper, he said that when he had first seen the title 'Pollution and the Community', his heart had sunk because he had thought it would reflect a preoccupation with Brussels but on reading the text he had realised that Mr. Haynes' community was spelt with a small 'c'. Mr. Haynes had made reference to reading the conference programme and applauding the fact that the subjects were more down to earth. Hiw own paper had been no exception,

and had discussed the pollution problems which continued to niggle and vex most people at some time or another.
Mr. Lovell agreed wholeheartedly with the comments on publicity, and said that apart from a handful of his colleagues, whose subject matter generally centred around clean food, he believed that not enough use was being made of local radio. The media was growing up and down the country; local authority officers had the initiative, and he felt they ought to go to local radio and give publicity to certain topics of which the public should be aware. Having said that, with impeccable timing, while he had been drinking his coffee that morning at 7.20, he had been delighted to hear a past chairman of the general council of the EHOA, Mr. Roy Emerson, talking on the BBC and commenting on the Annual Report of the EHOA, on one of the points that Frank Haynes had raised: the question of noise from domestic animals. In The Telegraph that day a similar report of 'The Real Good Life' had been published which was well worth reading and a good bit of publicity.

Mr. Haynes had talked about the question of the sale of coal in smoke control areas. It was a difficult situation. Clean Air, and subsequently Municipal Engineering, had reported that the previous year 98 shops in Newcastle were known to be selling bags of bituminous coal, the city having been completely covered by smoke control orders. He hoped that sufficient moves had been made in the right quarters to try and rectify that situation, where there was a definite loophole in the law as it stood.

Mr. Haynes had gone on to talk about the level of fines, saying that the levels were insufficient deterrent to people who were breaking the law. If he had meant the maximum prescribed, then clearly definite changes had got to be made. If he had simply been referring to the levels imposed by magistrates, Mr. Lovell hoped that Mr. Haynes would use his influence as a JP of some 12 years standing, or sitting, with his fellow magistrates, even though he might be disqualified from sitting on the appropriate cases.

On the control of development of industrial sites, Mr. Haynes had said that planners must ensure the processes carried out

on sites were compatible with adjacent developments.
Mr. Lovell hoped that it was not going to be left simply to the planners, as that would put the clock back severa years. Up and down the country, many local authority environmental health departments were liaising very closely with their planning colleagues. That had to continue and increase. The expression 'environmental impact' was widely used. Mr. Lovell believed firmly in environmental health officer impact, and that the initiative had to be taken by members of the profession; through their experience and knowledge of certain industrial processes they could help and liaise very closely with the planners to try and get rid of some of the problems that had occurred through lack of liaison in years gone by.

MR. I. W. BARKER (Director of Environmental Health, City of Sheffield) wanted to recount a success story because he believed that in the depths of the current economic winter of discontent, it was important that delegates should be reminded of the achievements of the Society and of local authorities. The City of Sheffield, traditionally and historically, had been one of the most vigorous exponents of clean air. The 1956 Clean Air Act had provided the legislative powers which had been eagerly seized upon by the City to translate its intense desire for atmospheric improvement into positive action, and the City had thus become a pace-setter, in the vanguard of all those local authorities who wished to pursue and had pursued a vigorous policy of progressive smoke control. The extent of the City's commitment had been manifested when it had become one of the first industrial cities in the U.K. to become fully smoke controlled in 1973, with the completion of its final smoke control area. Local government reorganisation had extended the city boundaries considerably, and a supplementary programme had been put in motion to bring the added areas under smoke control. The final order of that second programme was awaiting confirmation. Thus, the City of Sheffield continued to demonstrate its total commitment to clean air, and to justify its proud boast of having the cleanest air of any industrial city in Europe. Sheffield's achievement was worth recounting as an example of what could be achieved by immoderate resolve.

In May 1979, the Standing Conference of Co-operating Bodies had met in Sheffield, and Mr. Dudding of the Department of the Environment had given an account of the then proposed EEC air quality standards. In so doing, he had suggested that some local authorities might not be able to meet them in their entirety, and he had had the temerity, in Sheffield, to suggest that Sheffield might be one of them. Conscious of the sense of outrage that would have ensued if such a suggestion had been made in public, Mr. Barker had undertaken an extensive analysis of the readings from the city's 13 monitoring stations. His department had looked in particular at the recorded values for smoke and SO2 for the previous two years, and had assessed those against the standard as described in Mr. Evans' paper. For the purpose of the assessment, they had looked at the winter median values for the period October 1979 to 1st March 1980, at the annual median values for the period 1st January 1979 to 31st December 1979, and at the 98 percentile daily values for the year 1st January to 31st December 1979 and also the 12 month period of 1st April 1979 to 31st March 1980. The analysis had shown that none of the EEC limit values, as quoted in Mr. Evans' paper, had been exceeded, for any of the three standards, and he believed that Sheffield complied with the Directive. They had also looked at the guide values, and had found that in 1978, seven of the 13 stations complied on both counts, smoke and SO2, with the EEC guide values, and 12 of those stations complied with the smoke values alone. In 1979, the results had been 4 and 11 respectively.

That was felt to be a very satisfactory situation, but he did not believe that there were any grounds for complacency; indeed, Sheffield Environmental Health Department were conscious of the need to consolidate its achievements, and its officers were even more conscious of that need, having attended the conference and learned of the developments and the crises that were occurring in the world energy situation, which they saw as a threat to the achievements that had been wrought, because of a real possibility of a deterioration in the hard and dearly won gains in air pollution control.

What was required was positive, committed guidance from the government, on what to do in the future. He did not think local authorities were getting this guidance, from the

government, from the DOE or, with respect to Mr. Evans, from the paper he had presented that morning. The EEC Directive was a most revolutionary development for the U.K., in that it required the implementation of air quality guidelines. The U.K. had never had those before. Mr. Evans had written in his paper that the Directive was Community Law, and therefore that the U.K. was committed to it, local authorities had to meet the standards. But there was no information on the regulatory measures that were likely to be involved to enforce the directive. The Government had stated that it was committed to a continuing policy of clean air; they had demonstrated that by making it much easier to make smoke control orders, they had removed the requirement for submission to the Minister for confirmation and approval of the orders. But of course, they had also removed the requirement for any local authority to go to the Minister for approval or confirmation of a revocation order, and as Mr. Haynes had said that morning, local authorities trying to cope with ever-tightening budgets would look first at smoke control, because it had always been one of the easiest things to reduce, and it was going to be made even easier. Therefore, he wanted to endorse Mr. Haynes' crusading zeal and once again exhort conference and the members of the Society, and local authorities in cities in particular, to persist and to maintain the commitment and the zeal and the vigour in the execution of clean air.

<u>COUNCILLOR DENIS LOVELACE</u> (Bath City Council) had been very pleased to hear Mr. Haynes' contribution. Following on from Sir Derek Ezra's remarks on Tuesday, who had managed to talk about the future of the coal industry without once having to refer to the National Union of Mineworkers, delegates had then heard Mr. Haynes talking about a wide range of parliamentary and local government achievements without being able to define exactly where the power lay to do the things which delegates wanted to do. He meant that in no sense critically of Mr. Haynes but felt that he had really put his head on the block that morning. The first paragraph of his paper had enumerated with due pride the various things that Mr. Haynes had done in his life, as a trade unionist, a councillor, a county councillor, Member of Parliament, Chairman of a Health Council; Mr. Haynes had been all those

things, and it would appear that nowhere had he found the power, the success that he needed, that all delegates would wish him to have, to do the things which they all wanted to achieve. Cllr. Lovelace wondered exactly where power did lie in that field. Perhaps the Archbishop of Canterbury, for instance, had the same problem when it came to making decisions and getting achievements on the record book. For example, on the question of smoke control, his own local authority, Bath, had been one of many which had fallen over themselves at the time when the Labour Government had been making public expenditure cuts, to wipe out of its programme a smoke control policy. He wondered who had been responsible for that; the Government, which had cut public expenditure, the local authority members, such as himself, who, Mr. Haynes had said that morning, were responsible for deciding policy, and responsible for allocating finance, or the local government officers, environmental health officers who were responsible for implementing smoke control programmes, who had cut them out of the budgets because they had misread the Government's instructions. At that time, so many local authorities had taken smoke control out of their programmes that the DOE had issued a circular to say that it had not been the Government's intention that smoke control programmes should become subject to the finance cuts. He wondered who had the ultimate power, and responsibility. He was drawn to the conclusion that really power lay nowhere at all, it was something everybody talked about, nobody possessed and everybody wanted.

Turning to the situation with bonfires, and the byelaws which had been mentioned in Mr. Haynes' paper, he reiterated the point he had made the previous day that there were byelaws against all sorts of things, which by and large were unenforceable and which were largely ignored by people riding bicycles on pavements, allowing dogs to roam, etc. All local authorities had such byelaws and they were all ignored and evaded. In Bath, one of the Environmental Health Officers had written a few years before to the Minister at the Department of the Environment to ask whether it was possible to have some stronger byelaws against bonfires. The answer had been that the Minister would not consider it, because he was of the opinion that current byelaws, enforce-

ment, and arrangements were strong enough. There were two different points of view, someone saying on the one hand that stronger controls and stronger byelaws were needed and a Minister saying on the other hand that the necessary powers were available. Then there was his own view, as a local authority member, that those powers were unenforceable. He asked Mr. Haynes, as a J.P., whether it was not time to look at the whole question of enforcement, and the way in which local byelaws were enforced, through the courts, the time it took, the sheer inefficiency of the manner in which they had to be handled by the police, local authority officers and by Justices of the Peace.

COUNCILLOR R. FORD (Congleton Borough Council), commenting on Mr. Haynes' point that power lay, not with the civil servants, or the politicians, but with the people, people who elected their representatives, said that in 1979 his local authority had wanted to make a smoke control order. He had never, in his lifetime, seen such emotion displayed regarding the introduction of a smoke control order. The EHOs and councillors had been phoned up night and day, there had been letters in the press, there had been radio discussions, and in the end, the order had been defeated - defeated by the people themselves, in whom Mr. Haynes had suggested that the power lay.

On the other hand, his authority had recently introduced a partial pedestrian scheme. It would help to reduce pollution, as had been discussed earlier in the conference, by taking out cars, lorries, fumes and noise, and the inevitable waste of time, petrol and money, and again great emotion had been aroused in the people themselves against pedestrianisation. Therefore, he asked where the power for environmental improvement really did lie.

MR. M. O'BRIEN (Watford Borough Council) had been very pleased to hear the remarks made by Mr. Haynes. He felt that the Society had become very complacent, and that Tuesday's performance by the power people had been a real whitewash job. The speakers then had said that there was no need to worry about nuclear power, there was no need to worry about lead in petrol, there was no need to worry about

carbon monoxide, everything in the garden was lovely. On the question of the Phurnacite plant, the NCB reply had been that they could not afford to build a better plant. Mr. O'Brien said that if they could not afford it, they should get out of the game of manufacturing the fuel. If that complacent attitude was carried on within the National Society for Clean Air, members would finish up holding conference in a telephone box.

He had first come to the Society's conference in 1966, in the Winter Gardens at Blackpool, and it had been filled. He knew that, with local government reorganisation, there were far fewer authorities to appoint delegates, and that many rural-type authorities thought that clean air matters did not concern them. But the Society had widened its scope into the field of noise, and Mr. O'Brien felt that it was time to change the Society's name, to embrace other matters regarding environmental pollution. NSCA appeared to him to stand for the National Self Congratulation Association. He suggested that the title should be extended to make it the National Society for Clean Air and Environmental Protection, and that then perhaps some of those other authorities who did bother to send delegates would wake up to the fact that the Society was concerned about other matters, not only smoke and SO_2, and start sending delegates.

COUNCILLOR H. DALEY (City of Wakefield) asked whether the Department of the Environment regarded the air quality standards, as contained in the EEC Directive, as minimum - a floor and a ceiling, which local authorities had to get below, but having got there, the aim was to stay there. That was a real concern, and Mr. Barker from Sheffield had raised a similar aspect of it, as to whether or not it was possible, and whether Her Majesty's Government would encourage or discourage local authorities who were seeking to improve their air quality standards vis a vis the EEC standards. He asked whether it was Government policy to discourage or encourage local authorities who were seeking better air quality standards than those contained within the Common Market Directive.

He also asked whether it was Government policy to exclude

from smoke control areas those rural areas which were adjacent to urban areas. He had in mind a particular rejection in his own Wakefield MDC area, whereby a grassland area, rural in character, had been rejected when in fact it had been a bridging area between the mining areas of Featherstone and Sharlston and Normanton. The area had been one between and adjacent to, those mining areas. He therefore asked Mr. Evans whether it was current DOE policy to exclude those areas which were basically rural but adjacent to urban, heavily industrialised areas. He said that the nil or low expenditures in bringing about smoke control, because of the essential greenness, should be particularly borne in mind. His final question was whether the policy of the Government, in refusing to confirm smoke control areas, albeit under the hat of the new EEC Directive or under the hat of the quasi-rural urban areas, was a disguised means of reducing public expenditure without being open about it, using other means than those publicly announced by the Minister and debated in Parliament. He hoped that Mr. Evans would be able to comment frankly and openly on his last question.

MR. C. R. WHITE (London Borough of Hackney) believed, with respect to Mr. Barker, that the honour of being the first completely smoke controlled area had gone to Hackney. Paul Evans had said, in relation to future availability of energy, something like "We shall have to have flexible standards to meet the varying demands". Mr. White wondered who Mr. Evans had meant by "we' - the UK or the EEC. Bearing in mind the lack of control over EEC matters by the UK, apparent in recent negotiations, he asked Mr. Evans how far he felt the UK could influence treaty decisions on EEC air quality standards. Referring to Mr. Lovell's remarks, Mr. White thought he had fallen into the old trap of taking a minimum standard as the standard. He was sure that, despite some views that had been expressed, the majority of delegates needed no reminding that what should be striven for was the best that could be achieved. It should also be remembered that what happened in area A affected the air quality of area B; just because everything seemed fine in one area did not mean that weeds were not blowing over into someone else's patch.

MR. F. REYNOLDS (Leeds City Council) asked Mr. Evans, who had referred to the prospective consultative document on the EEC Directive, whether it was the Government's intention to enforce, through legislation, individual local authorities to carry out smoke control in specified areas which did not comply with the EEC Directive.

Secondly, in relation to the question of finance, which was obviously attracting considerable attention, Mr. Reynolds said that it was currently intended that the Rate Support Grant would not specify how the monies should be expended. That was in general agreement with the Local Authority Associations' wishes to have freedom to determine local priorities. But Mr. Reynolds asked those delegates who were particularly concerned about smoke control and possible local cutbacks whether they were more inclined now to consider specific grants for various aspects of environmental control work rather than the more general Rate Support Grant.

Thirdly, on cost limits for smoke control, he said that the cost limits which had been determined by the DOE for many years had been a long way behind inflation. In 1980 those cost limits had been increased but his colleagues advised him that they were already out of date. He was sure that appliance manufacturers and those from the gas, electricity and solid smokeless fuels industries would all agree that they should be increased even further. Local authorities also knew that they should be increased even further. He asked Mr. Evans whether it was likely to be DOE policy, as part of the relaxation of controls, to enable local authorities to determine their own cost limits, bearing in mind the general policies which had been adopted in the past of not being too profligate.

Finally, turning to Frank Haynes' paper, Mr. Reynolds said at the very end Mr. Haynes had made reference to the control of development on industrial sites, and the chemical incineration plant which was causing odour problems.
Mr. Haynes had written "This plant meets the standards of the Alkali Inspectorate, but still causes nuisance to nearby inhabitants". Mr. Reynolds said that firstly, the planners should perhaps not have allowed the development of the

chemical incinerator on that site, and perhaps one of the District Environmental Health Officers ought to have commented on the proposals. His second point was to question whether the standards of the Alkali Inspectorate were sufficiently high; indeed he asked what action they had taken in order to attempt to improve matters and pursue Best Practicable Means. Whenever public pressure had been exerted against a particular industry and the Alkali Inspectorate to justify bpm, almost invariably a "better bpm" had been found.

MR. E. FULLER (Rotherham Borough Council) said that the Royal Commission's Fifth Report in its reference to rural areas, together with the EEC Directive, had produced a major disservice to the cause of domestic smoke control. The mandarins of government, whether they were civil servants, or ministers, had invoked those two factors and probably more, to refuse confirmation of a smoke control area in Wakefield. He thought that delegates would wonder what on earth those in Whitehall knew about industrial villages in Yorkshire. The answer, quite simply, was nothing; because it was certain that the friendly, local neighbourhood councillor from a mining village would never risk his re-election on smoke control if his parishioners did not agree with it. It was equally certain that no miner would agree to lose his concessionary coal, if he or his wife were not going to get something in return. He knew that he would get clean air, and he wanted it, and no unfriendly, remote, long-distance mandarin in Whitehall had any right to interfere; neither, with respect, had the Royal Commission on Environmental Pollution, and nor had the EEC. A village, planted in a rural area, was just as much in need of smoke control as a built-up, larger area, because domestic smoke control was local; smoke emission affected neighbours, and if a thousand dwellings on the outskirts of a town, and contiguous with it, needed smoke control, then a village of a thousand houses also needed it. If it happened to be a mining village, it needed it twice or three times as much, because a miner's concessionary coal consumption was that much greater than the average. He thought that any one of Rotherham's mining villages, of four or five thousand population, set in rural surroundings (there were such

villages in South Yorkshire, also), would produce not less than 200 tonnes of smoke per year, from domestic coal fires. And most of that was thrown out in the four winter months, and all of it dumped within half a mile. Experience gained locally, and that was a vital aspect that had been mentioned before, showed that such places needed domestic smoke control.

The EEC standard appeared to have been set at what was easily achievable, not what was desirable. To use it as a standard below which smoke control was not necessary was not to understand practicalities. Gauge readings could not be relied upon as being representative of the whole district, because the best site for the gauge often did not give the worst readings. Gauges had to be sited with regard to ownership of land, vandalism, etc., as much as air quality. In any event, gauges could not measure the obnoxious smell which was one of the biggest problems of domestic smoke. There were many reasons for not leaving the decisions on smoke control areas to the Ministry or the Government. It had to be dealt with by the local authority, and it was sufficient to say that if the DOE insisted on interfering, it would lose friends in local authorities. He asked whether the real reason for the DOE's attitude was merely to support the Government's somewhat strange economy drive, and whether the NCB had successfully lobbied Whitehall to ensure that it could retain its domestic coal market.

MR. I. MACPHERSON (City of Glasgow) said that the important point, in relation to monitoring, was that whichever local authority was monitoring at that time was intending to implement smoke control. He asked what the Government was going to do in places where local authorities were not going to monitor, and whether there was any plan for such areas; where no monitoring was carried out, nothing could be known about air quality. If school projects were created, and schools did everything correctly to WSL standards, including monitoring in the area, he asked whether the school or a local pressure group could then take the district council to task if the EEC standards were exceeded and ask them to do smoke control. Then there was the question of changing legislation; MPs were never afraid to change legislation.

Mr. MacPherson asked why the legal definition of dark smoke could not be changed. He suggested dropping it by a Ringelmann number; that would be simple and positive action.

MR. A. J. CLARKE (Chairman of Council, NSCA) referred to Mr. Haynes' questions concerning the role of the Society and how they could recover their crusading zeal. He assured Mr. Haynes and the delegates present that the question was uppermost in the minds of Council at the present time. Similar doubts about whether the Society was heading in the right direction, covering the right subjects and so on had been expressed, perhaps less forcibly but just as sincerely, by many Society members in the previous year or two. The preceding Chairman of Council, Mr. Fuller, had begun the formal process of re-examination, helped considerably by the comments of the Secretary General resulting from his many years of experience. It was not a matter to be hurried through quickly; it required a lot of thought. The Honorary Officers and Secretaries of Divisions at their meeting the previous day had been asked to consider these matters and communicate their ideas to Council.

Mr. Clarke stressed that the re-examination would cover the whole spectrum not only of the Society's activities but its internal structure and committees too; even the name of the Society itself. A Committee of the Honorary Officers of Council and Chairmen of Committees had been appointed solely for the purpose of the re-examination and hoped to begin work very shortly with the aim of presenting specific recommendations at the next Annual General Meeting. Mr. Clarke added that widening the scope of Conferences had clearly been successful and that he could detect much agreement with the kinds of programme provided recently.

Mr. Clarke added a note of caution; the Society needed rather more than just crusading zeal. There were other environmental organisations with plenty of crusading zeal but with very little technical knowledge and little sense of responsibility for the consequences of their demands. Over the years the Society had achieved a great deal of objectivity; the word 'balance' had been used earlier in the week. Whilst there was always a danger that balance could lapse

into complacency (a point made by a previous speaker) a balanced outlook was nevertheless essential and for that technical knowledge was also essential. If the Society was to make responsible decisions on difficult matters then members had the obligation to learn about those technical complexities and it was part of the duty of the Society to include such matters in Conference programmes as had been done over the years.

COUNCILLOR A. LOCKE (Craigavon Borough Council) said that the Honourable Member had put his foot in it. A man after his own heart, he asked whether Mr. Haynes realised that the councils in his own area of the UK had been decimated, reduced by two thirds, and were living in a state of change. Although it was the 47th Conference of the Society, there had to be changes. That was the order of things. Quite recently the advantage of being members of the Society had been demonstrated. His council had been discussing a very vital smoke control zone, to complete No. 8 area, and indeed the feelings of most of the members before the meeting had been that they were going to axe the order on the basis of the economy cuts, about which so much was heard. He believed that if it had not been for two council associate members putting up a very strong case, as to why the council should go ahead with it, the order would have been lost, and progress in smoke control might not have been recovered for a considerable time. Mr. Haynes had been quite right to say that the Society needed zeal but Councillor Locke questioned whether vast numbers were really needed. After all, delegates were not coming to see a big show; they were coming to a nice area, to meet lovely people; he felt that the delegates, members and officers, went home renewed with a sense of urgency on clean air and smoke control matters.

MR. C. C. H. FRY (Warwick District Council) said that his authority was within two years of completing its smoke control programme for the urban area. At that time, the greatest pressure was from the public and press who asked where the pollution was. That was perhaps a reasonable question as the smoke control programme to date had achieved a dramatic reduction both in smoke and sulphur dioxide levels. The EEC Directive, however, would do little to help

his authority, and many others, to complete its programme, because sulphur dioxide and particulate levels did not at that stage exceed the prescribed levels. He accepted that Mr. Evans could not speak on behalf of HMG, but he was concerned about his remarks concerning selectivity of future smoke control areas. He emphasised that it was important for local authorities to complete their programmes, to avoid the situation where there were two classes of citizens, one forced to use smokeless fuels and the other free to pollute the air without there being any recourse to law.

COUNCILLOR T. HARRIES (Mansfield District Council) said that Mr. Reynolds of Leeds had taken up part of the question he had wished to raise regarding financing the speed-up of the smoke control programme to meet the EEC standards within a certain time. However, he wondered what pressure that would put on the health teams. There had already been directives from Government over the previous two years regarding the Health and Safety at Work Act. Extra pressure and extra work would be involved, with no extra finance to cover it. At that time, the plea was for local control down to local level, and yet there was the DOE directing from above. He felt that sometimes the finance angle was skated over by some of the members on the platform, and that they were not too much bothered about it. But it affected authorities at local level. He wanted some comment on government-induced extra workload.

He asked Frank Haynes, who was familiar with the problem in enforcing smoke control orders, about the effect of the unemployment position; some people were working a two-day week, some just a basic week, which meant that there was no money for extras. He felt that the position of the unemployed was further depressed by the Government's policies, and the dole monies available to those people were also depressed. He wondered where heating came in the priorities of such people. He felt it came third; rent or mortgage, then food, then heating in the home. The cost of smokeless fuel was very high, and there was maybe a tendency, by one devious means or another, to burn the cheaper fuels which contravened the Act. People had to heat their homes; if it was a bad winter, they had to keep their children warm. He

felt that some thought ought to be given to the position of such people, e.g. the use of cheaper fuels in smokeless appliances or other means of supporting fuel bills.

MR. K. TEESDALE (Ford Motor Co. Ltd.) addressed his question and a few remarks to Mr. Evans. He said that he himself was not an expert on smoke control orders, but was very much involved in his job in dealing with the EEC and other international institutions. Many speakers had knocked the EEC, but it was there, the UK was a part of it, and to an extent it could be argued that people in the UK should get into the institutions of the EEC, as far as possible at every level, and make better use of them. The UK was historically a premier democracy, and many of the institutions which were developing, like the reorganised European Parliament, had been based largely on British models; there was thus more chance for traditional UK institutions and the very 'caring for the community' which had been demonstrated by many speakers at the conference, to be put into practice. The EEC should not simply be criticised; it should be used.

His understanding was that Directives were not necessarily binding on member states in absolute exactitude, but were binding as to objectives. If that was correct in the case of the Smoke & SO_2 Directive, he thought that many of the concerns that the local officers had mentioned could be taken care of; so long as the general objectives of the Directive were met, they did not necessarily have to be followed rigidly on the lines of the particular wording. Also, of course, as had been mentioned, they were minimum standards, which could always be improved upon.

Finally, he thought that as the UK had to pay to join the Common Market and stay in it, it might be possible to get some of those funds to offset the kind of problems exemplified by the Phurnacite plant, where a local community had to suffer an exceptionally difficult environmental problem for the good of a wider community, either within Britain or even outside, and the Government of the day was unable, because of its financial policies, to give a special grant. He asked whether that was not a typical case where EEC funds might be syphoned off to the benefit of the UK.

COUNCILLOR C. HOBBS (Rhymney Valley DC) said that during the discussion reference had been made to the general public and their attitude to environmental problems and pollution. He asked Mr. Evans what his department was doing to educate the public and indeed industry together about environmental problems which local authorities had to face, both at member and at officer level. In the mining valleys, as had been explained by the Welsh delegation, it seemed that there were two areas, which emanated from the fallacies put about by local authorities, one for those with a cough and one for those without a cough. He felt that a clean air conference might well have been convened in a mining valley, where people like Mr. Evans could see the problems which those sort of people had to endure, rather than in an area such as Bournemouth, where there appeared to be no environmental problem.

MR. G. R. CHARNLEY (Southampton City Council) said that Mr. Haynes had mentioned briefly in his paper the possibility of restricting hours on bonfires. Mr. Charnley felt that many local environmental health officers following up complaints about bonfire smoke would have heard the offender say 'Oh, I thought there was a byelaw which permitted me to light my bonfire after 6 o'clock at night'. That was a fairly common belief. He said that he liked to go out in the garden at 6 or 7 o'clock in the evening and smell the perfume from the flowers. His children also liked to go to bed between about 6 and 7 o'clock at night, and they liked to have their bedroom windows open! He was really trying to sound a note of caution. S.16 of the Clean Air Act, in all its legalistic terms, talked about causing nuisance to people; it did not restrict the times, it just talked of causing nuisance. In lay terms, it went back to what had been discussed throughout the conference to a certain extent, the need to be considerate. He suggested that local authorities should be wary of restriction of hours in making local byelaws; it might only serve to legalise unnecessary pollution.

Turning to the EEC Directive and the setting of standards, he said that by and large the UK had a reasonably responsible approach towards monitoring. There were monitoring stations fairly well located in the problem areas throughout the

country. But he wondered about other nations in Europe, and asked how many monitoring stations they had, and where they were located. He said that it was possible to meet the standard purely by altering the actual location of the monitoring station. The numbers of monitoring stations were also important. He asked Mr. Evans who would monitor the monitors.

MR. E. W. FOSKETT (City of Manchester) spoke on behalf of the City of Manchester and also the Manchester Area Council for the Control of Pollution. A great deal had been said about the refusal of DOE to confirm smoke control orders in rural fringes; it was an issue which had certainly been before the Manchester Area Council for Clean Air and Noise Control, and he suspected that the City of Manchester had been one of the local authorities which had caused the problem to be brought into view. It had been brought into view in a rather interesting way, which perhaps would throw some light on the problem. In 1974, in local government re-organisation, the City of Manchester had gained very little territory, but it had gained just a half square mile of rural intrusion into the urban fabric, a rural intrusion on the south westerly border of the City. The first of the City's smoke control areas had been established on that border many years before and there had always been an intrusion of smoke-producing properties. That newly added area had been, he thought properly, made into a smoke control order, because it was equitable for that to be done, because of the response of the citizens who had for so long been subject to smoke control orders and had for so long been subject to the drift of smoke from that small area into the City. The order had gone to public inquiry, largely because the Parish Clerk had been a solicitor by profession, and had chosen to take on the City Council. The City had won, but had also gained notoriety by appearing in the Fifth Report of the Royal Commission on Environmental Pollution, and had been the originator of that particular paragraph to which reference had been made.

On the question of equity, he asked how equitable it was for the DOE in Whitehall to make judgements which were more validly made in local authority areas where they understood

the people and their needs, and understood the need to divert resources to deal with those particular problems. There was an element of equity in that which frequently seemed to be missing. On smoke control orders, one of the essential points was that frequently in the past resources had been frittered away by the delays in confirming smoke control orders, which had increased the cost of their ultimate implementation, money which might have been better spent on promoting other smoke control orders. That brought him to another very important point. He asked whether, in the event of local authorities getting power to make their own smoke control orders, the Government was going to play ducks and drakes with them by ensuring that money was not found within the RSG or whatever superseded it, for financing smoke control. It would be cynical if local authorities were to be given powers with one hand, and then denied the means of implementing them with the other.

The question of where power truly lay had been raised earlier. He suggested that the power lay very firmly with local authorities themselves. They chose to do what they chose to do. The Manchester Area Council for Clean Air and Noise Control had, on a number of occasions, deliberately chosen to issue advice and guidance to its constituent members, and one of the early pieces of guidance that had been given had been when local authorities had been urged to cut public expenditure. The Council had deliberately referred its members to the financial White Paper, and drawn their attention to the fact that it had stated quite clearly that local authorities were entitled to determine their own priorities, and also to the fact that the funds to be spent on environmental services had been in fact more lightly reduced than most. The Council had hoped that in those circumstances its member authorities would feel free to continue their smoke control programmes; in the Council's area, which covered a population of some 3½ million people, most of the local authorities appeared to have taken that advice to heart. The Council had also issued some advice on another occasion, and the only local authority to protest against it was the only one which had no pollution control functions.

COUNCILLOR JOHN HUGHES (Halton B.C.) explained that Halton was a district consisting mainly of Runcorn and Widnes and outlying villages, which had therefore a rural strip. The authority was proud that it had, and not recently either, completed 100% smoke control orders. Bearing in mind that most district councils, as far as he knew, were members of the Society, it appalled him that so many districts did not seem to have fully completed their smoke control programmes (some had not even started). Halton had achieved full smoke control; it was a low wage area, an area of high unemployment, typical of many areas in the North West, and the completion of the programme had been achieved in the days when the previous government had been imposing expenditure cuts on local authorities. It was a mainly urban and industrial area, the home of the chemical industry in Britain. It had every pollution problem and every odour problem imaginable. While the smoke control programme had been completed, the authority was still pressing on with the other problems of odour and pollution. It was not resting on its laurels.

But while it did appal him that so many local authorities had done so little, on the other hand, he realised from the discussion that there could be reasons why many councils had not been able to complete their programme. He wanted to know exactly why it was so, and felt that others, members of the Society who were dedicated to clean air in every sense, would also want to know. He thought that the Society could do a very useful job if it would complete a survey of the average number of applications for smoke control orders for any given year and the percentage of refusals and the reasons for those refusals; he thought that if the Society could put such information out to its members, they would be doing a very useful service.

MR. P. EVANS, replying to the discussion, said that he had been most interested to hear the discussion about power and responsibility. Everybody had seemed agreed that he should not have the power, and then everybody had asked him the questions. Councillor Hobbs had asked whether the Department or the Government was going to embark on some sort of programme of education. Mr. Evans thought that it was unlikely, but that from what had been said possibly the Society was in

a position to take on any programme of education that might be needed, as it had been doing over a long period.

In answer to the question of whether the two orders that had not been confirmed recently were in some subtle and hidden way an aspect of public expenditure cuts, he said that they were not, and indeed he thought that legally they could not be. Although he gathered that it was proper for the DOE to impose a moratorium on smoke control, as happened in 1975, DOE could not simply refuse to confirm orders on the grounds of lack of finance. Each order had to be considered on its intrinsic merits.

On finance, Mr. Reynolds had asked about the cost limits, which had in the past lagged rather badly, and whether DOE were going to do something about them, or indeed, allow local authorities to set their own cost limits. He could not give a detailed answer; when local authorities saw the DOE description of the possible new procedure, it would be evident that there would have to be some cost limits within it. Quite what they ought to be, and how they ought to operate, and how often they ought to be revised, was something which DOE would hope to discuss further with local authorities.

On the question of grants, block grant as it was called, he had been asked whether DOE were going to frustrate local authorities by giving them all those wonderful new powers and then saying that there was no money. Mr. Evans' understanding was that the block grant did not contain money in relation to smoke control, which was a capital grant and fell into the new capital control system. Whilst there would be an overall sum of capital allocation to individual authorities, it would be open to them to set their own priorities between various forms of capital expenditure, of which smoke control would be one.

The nub of many of the comments had been, he thought, really aimed at his remarks about priorities, in the application of smoke control. The DOE certainly did not think that the need to attain the EEC standards in some reasonable, foreseeable period of time, meant that everywhere that had

attained them, or subsequently attained them, needed to do no more about air pollution. First, there were the guide values, which provided some impetus towards continuing long-scale improvement. There were also substantial arguments made by various speakers of equity between one part of the community and another. Although some degree, and in terms of the Directive, sufficient degree of control of air pollution might be achieved by controlling some part of a city, some of the speakers had reasonably been suggesting that it was hardly fair to impose the costs on one part of the community for the benefit of the whole community, and that there might be a reasonable argument for the continuing application of smoke control even when standards were reasonably achieved. He thought DOE would accept that. When he had talked about selectivity and priorities, he had not meant that there should only be smoke control where it was necessary to comply with the Directive. Selectivity did mean, however, that if finance, as seemed inevitable, was tightened continuously, some higher priority ought to be given to those areas that were still above the limits which were agreed as a reasonable health protection level.

Some other questions had been directed to the exclusion or inclusion of rural areas in smoke control orders. Mr. Evans agreed entirely that it was not right for DOE to take those decisions; they were enormously difficult decisions, and in future DOE would not have to take them, so long as the Local Government Bill was passed and the power of confirmation died. However, they were invariably taken in the light of Inspector's Reports, where local inquiries had been conducted and a view taken after inspection of the area. Although the local council might think that their parishioners wished for smoke control, it was astonishing how many objectors got up at those inquiries and said that they did not. The Inspector had to balance those views and provide recommendations to DOE; at the time of speaking, DOE had to take a decision on grounds of the individual merit of the order and conformity with a general approach to the whole problem. However, local authorities would be making their own decisions in the future, and the inclusion or exclusion of rural areas would be something for them to discuss with the people who actually lived there.

A number of other questions had centred on the UK's relations with the Community, for example whether the DOE had been adequately involved with the early discussion of directives. His predecessors, rather than Mr. Evans himself, had been active in negotiating the Smoke & SO_2 Directive, and had tried to ensure that it was a Directive which would be wholly compatible with the objectives which DOE wanted to attain in the UK on air pollution. DOE continued to be closely involved in any suggestions for moves of that kind on other pollutants.

As to the availability of funds, he said that Europe was kept very closely in mind as a potential source. On the particular case that had been mentioned, of the NCB Phurnacite works, he thought that such fundings had been in people's minds. He thought that there had been other considerations, and in the event it had not been pursued.

On the question of the basis of the Directive, it was law, one of four categories of Community Law. It was binding on the UK, although he did not know how a law that said that air should be of a certain quality could be enforced. There was nobody who could individually be blamed for air not being of that quality, and it was not therefore an enforceable law that was going to result in individuals ending up fined or imprisoned. But it was still something on which the Commission would wish to see a common approach adopted, and eventually a common adherence to the standard.

Finally, someone had suggested that other people might think that the easiest way of complying with the Directive would be simply to move all the monitoring stations. While that might be so, Mr. Evans said that those who attended the Standing Conference would hear more about the proposed plans for rearranging the monitoring system; they did not involve trying to dodge the issue, and the Directive itself said that monitors should be provided at places, in essence, where they were needed to find out whether there were breaches. The extent to which that would happen in other countries was something which the Commission would no doubt be anxious to keep an eye on, and something on which there was a fair amount of interchange across Europe, so that

exactly what was happening in various places could be seen.

MR. FRANK HAYNES, MP, (replying to the discussion) said, on the point that Mr. Lovell had raised, that he himself had served as a magistrate for some considerable time but had been disqualified since taking his seat in the House of Commons. In his own experience, if somebody broke the Clean Air Acts by causing smoke emission from a domestic chimney, they usually received a letter from the local authority by way of an initial warning. He had known a second letter to go out as a warning without use being made of the law and the penalties that could be used by the magistrates. He pointed out that it was not possible to influence magistrates in their decisions as to the penalty imposed. Magistrates had to base the penalty on the merits of the case itself. However he did agree that generally penalties imposed at the present time were nowhere near severe enough.

On the question, which had been raised by several speakers, of where the power to improve the environment truly lay, Mr. Haynes said that he had dealt with the aspect of magistrates. He believed that the power lay with the people themselves. When a member or a candidate offered himself to the people locally, he stood on some sort of platform as to what he was going to do. As for himself, when he sat in Parliament he did not represent Frank Haynes, he represented the people in his constituency, no matter who. His constituents told him what to do as he was representing them, not himself, and he believed that the power should come from constituents as far as local government representation was concerned. However, he hoped that delegates would not feel that he had been disrespectful to civil servants and local government officers. They had a job to do and it was necessary to consult locally on the various problems but in the final analysis the elected members made the decisions. Therefore he still believed that the power lay with the people who elected the members, whether at local or national level. There were pressure groups of all sorts at local level which tried to push the elected representatives in a certain direction to do certain things. Members of local authorities had to take note of what was happening as far as pressure groups were concerned and do their very best to sort out the

problems.

He thanked Mr. O'Brien for his support and then turned to the point made by Mr. Frank Reynolds on the chemical incineration plant referred to in Mr. Haynes' paper. Mr. Haynes said that he regretted that he could not give a proper answer to Mr. Reynolds as the whole question of the plant was sub judice. The matter had been to the local magistrates court and had been referred to the county court. As far as he could express an opinion, he believed that the mistakes had been made in the very beginning when the planning application had been put forward.

Turning to Councillor Locke's comments on the Society, Mr. Haynes agreed that the Society had grown smaller, especially in terms of the numbers of local authorities that participated in its affairs. He himself had worked very hard to persuade the Nottinghamshire County Council to join the Society and in the end had been successful although subsequently the County Council had withdrawn. Mr. Haynes said that he would hope that every local authority in the land would join or be associated with the National Society for Clean Air. If that could be achieved, greater progress in the achievement of the Society's objectives could be made.

Councillor Harries had mentioned the question of the cost of fuel for the unemployed or the less well off. Mr. Haynes said that the Government were at the present time giving a heating allowance to the elderly who were a lot worse off than many people. There was a means test as far as the grant was concerned. He felt that much more should be done in that direction, bearing in mind the employment situation that Councillor Harries had raised. In the present economic climate, with unemployment rising daily, anyone was liable to become unemployed and to need help with heating and other bills. Mr. Haynes felt that the government of the day, of whichever party, should play fair in that direction, to help those who could not afford to help themselves.

On the question of bonfire byelaws, Mr. Haynes said that smoke from garden bonfires often caused a great deal of

nuisance to people. He asked delegates to imagine themselves on a Sunday evening when they were expecting visitors on a beautiful sunny day towards sunset and, as they showed their guests to the meal laid out on the back lawn, lo and behold, the chap nextdoor lit a bonfire and the whole scene was covered in smoke. Nobody enjoyed that sort of situation and local authorities had to try and deal with the nuisance. In November of the previous year, the district council in his own constituency of Ashfield had acted in the right way on the matter of bonfire smoke. A Guy Fawkes bonfire had been planned for a particular area and families in the locality queued up at the local Environmental Health Department Office to complain about the siting of the particular bonfire. In a flash the Environmental Health Officer decided that something had to be done and changed the site so that it would not affect anybody adversely. Mr. Haynes thought that this was how the matter had to be approached by all local authorities; it was necessary to adopt a commonsense approach. He believed that there was a need for byelaws so that the local officers could use them as a basis for action, but at the same time there should be some sort of flexibility.

SESSION 6

OPEN DISCUSSION

PANEL: Mr. Frank Haynes, MP; Mr. Paul Evans, Department of the Environment; Mr. M. F. Tunnicliffe, H.M. Alkali and Clean Air Inspectorate and Mr. Frank Reynolds, Director of Environmental Health, Leeds City Council.

MR. G. R. CHARNLEY (Southampton City Council) asked how, in terms of the Fifth Report (of the Royal Commission on Environmental Pollution), i.e. the best practicable environmental option, the panel saw the role of noise abatement zones fitting in and specifically their strengths or particularly perhaps their weaknesses in application. The Alkali Inspector, whilst suggesting means of remedying a dust, odour or other problem, seemed to pay scant regard at times to the noise situation; he wondered how the Alkali Inspector saw his role being fitted in with the other pollution control authorities.

MR. TUNNICLIFFE, replying, said that the Inspectorate had no statutory powers or involvement with noise controls. Its duties were entirely air pollution control and involved requiring companies to install equipment of various kinds to control air pollution. It was expected that the installation of air pollution control equipment would be treated just like any other piece of engineering plant, and that the equipment would be designed with the appropriate noise standards in mind. The Inspectorate did not specify what should be done in the matter of noise control. Inspectors were well aware that, for example, the operation of fans or filter plants are potentially noise-generating operations and in discussion with individual works, no doubt that matter would arise. If Inspectors saw that a sensitive situation was possible, with housing or other public areas very close to a factory, he thought that they would remember to bring it to the attention of the management. But they would expect as a matter of course that when installing equipment, the works management would remember and take account of whatever noise requirements were in existence.

The Inspectorate also had close liaison with local authori-

ties, and where equipment was going into a factory to control air pollution, inspectors sould have discussed it with the local authority Environmental Health Officer and he was sure that matters such as taking precautions against noise would come up during those discussions.

MR. F. REYNOLDS thought that Mr. Charnley had referred specifically to Noise Abatement Zones rather than the general problem of industrial noise from pollution control equipment. The two problems were somewhat different, because in the case of the Noise Abatement Zone, the local authority would be instructing the industrialist or whoever was in charge of the plant to ensure that it was sufficiently quiet to avoid any increase in the environmental noise levels. If any increase in registered noise levels in a Noise Abatement Zone was anticipated, the industrialist would have to seek the specific authority of the local authority. What he believed Mr. Charnley was seeking from Mr. Tunnicliffe was an assurance that the Alkali Inspectorate would advise the industrialist to seek the advice and observations of the local authority before the plant was installed. Relating that back, though, to best practicable environmental option in terms of the Fifth Report was a little more difficult.

Noise was an unwanted by-product of a whole range of industrial processes, whereas the plants which produced that noise were there for a specific reason, normally either to produce something or to prevent the production of something in the case of dust arrestment plant. The problem was to relate noise (the production of noise or the prevention of noise and its costs) to the prevention of dust or the prevention of an air pollution situation or, as a result of air pollution prevention, to a slurry problem which might arise from a wet washer plant, for example. The answer was, he thought, that they could not be directly related; all that could be done was to ensure that the noise climate of a particular industry was not increased by reason of the new plant going in. If that meant the plant had to be enclosed in an acoustic enclosure, or that it had to be silenced, muffled and so on, then so be it. If that made the cost exorbitant and put the plant outside the financial range of the person who originally intended to install it, then it

might be necessary to re-examine the whole scheme. It might be necessary, in the case of a noise abatement zone, to give authority for a slight increase in noise in order to achieve the air pollution control which might also be required, either by the Alkali Inspectorate or by the District Council.

MR. F. HAYNES, MP, said that in his constituency there was a factory making aero engines. The factory had been there before properties were built around it, and so a problem had arisen later. There had been a certain amount of progress made in the field, so much so, that on a recent visit to the factory itself he had discovered that it had just won a massive contract for the introduction of a brand new aero engine for the Boeing 747. There was of course the question of noise associated with the work. People queued up at his surgery on Saturday morning in that particular area, with complaints about the noise and vibration, because those people worked different shifts. When they were trying to sleep through the day - and he added that the factory tried to keep the noise element to the minimum at certain hours of the daily 24 - having done shiftwork, it was a bit difficult. However, all sorts of people had to get together to work the problem out once and for all for everybody concerned. He did not believe that the responsibility lay in any one particular area, or that it was a case of pushing it on a certain department, a certain individual or group of individuals.

He believed that people knew about the question of noise. As far as he was concerned, against pollution such as smoke and dust etc., problems of noise were relatively new. It had to be remembered that it had not been that long since noise control measures had been introduced into the mining industry. With all the difficulties that there were working actually on the job on the coal face in relation to noise, where machines were brought down on to the job and if noises were at a certain level, it was round the table quickly to see how the problem could be overcome because it might interfere with production.

That was the case with the aero factory at the moment, because there were a lot of people complaining about what was

happening. Mr. Haynes said that he was trying to negotiate with the Minister himself with a view to the Government putting in some money to try and cut out the noise. The factory had to have testbeds for the aero engines in certain areas; some were inside, but other had to be outside. However, he was fairly convinced that if everybody would work together, it would be possible to work out the answers to the problems.

MR. G. R. CHARNLEY said that Mr. Tunnicliffe had given him more or less the answer he wanted: that ACAI Inspectors would tell industrialists, at the time they were advising them to install pollution control equipment, to contact the local authority, because there might be severe noise implications if they were not careful and perhaps their local authority could then give them suitable guidance. He had asked a rather mixed bag of questions, but he hoped that Mr. Reynolds and Paul Evans would comment on the noise abatement zone situation. Very few noise abatement zones had been declared in the Country, about 30 altogether and none at all in Leeds, which might be expected to have some of the noise problems, in Manchester and other large conurbations such as Bristol, or even Southampton. He wondered why that was so, and asked what Mr. Reynolds felt were the strengths of the Noise Abatement Zone Procedure under the Control of Pollution Act.

MR. P. EVANS explained, to avoid confusion, that he did not in fact deal with noise. He dealt very strictly with air business and such little as he knew about DOE's noise business had been picked up merely by talking to people in the corridors. He gathered that rather like Smoke Control Order Orders, the initiative for noise abatement lay in the hands of the local authorities.

MR. F. REYNOLDS was not quite certain of the current position on the numbers of noise abatement zones that had been declared but, as Mr. Charnley had said, there were very, very few, relative to the numbers of local authorities and the ultimate potential. By the end of 1979, 24 orders had been confirmed. The great difficulty in declaring a noise abatement zone, of course, was the commitment which the

local authority put upon itself. The monitoring required immediately following the declaration of a noise abatement zone, in order to register the noise levels for an individual premises, was an enormous task, in terms of time and staff. Although he applauded the concept of noise abatement zones, which had been recommended by the Noise Advisory Council in its publication, "Neighbourhood Noise", he firmly believed that the modus operandi was about the worst possible, with the limited resources of most authorities, in order to produce the effect that was desired. No amount of noise monitoring ever reduced a noise; it merely indicated what that noise level was. An engineering survey and an engineering answer to the noise problem was then required.

Mr. Charnley would know that it was one of Mr. Reynolds' hobby horses: he had been a lone objector in the Noise Advisory Council in the 1973 period when the Control of Pollution Act was being framed, in that he had suggested that noise monitoring was not desirable as part of the process. What was really necessary was for a local authority to say, "We are going to declare a noise abatement zone in this particular area", then to delineate it on a plan, and it would then become a duty of the industrialists and the others in that area to co-operate with the local authority and conduct an engineering survey to determine how best to minimise noise from their premises. That really was what it was all about. Out of all the noise abatement zones that had been declared so far, he understood that less than ten premises had actually been monitored to put on the noise register. And that in itself, he thought, indicated complete failure of the modus operandi described as necessary in the Control of Pollution Act. He said he would dearly love to see a revision of the method in order to get some progress.

COUNCILLOR TOM HARRIES (Mansfield District Council) said that the end product of any excess noise in enclosed places was industrial deafness. He felt that it was all very well to talk about peripheries or boundaries outside the premises, but that the people that were suffering from within enclosed places deserved a mention. He believed that the high noise levels in enclosed places should be looked at more intently

by local government when granting planning permission, and that the control of such places should be carried out more strictly by the management. He understood that compensation for industrial deafness was only given by the DHSS to boiler makers. Government ministers had said that there were not enough audio specialists or consultants in noise induced deafness on the books; therefore the examination and registration of claims was in limbo. Noise could be regulated but he thought that it should be done at source, and he asked for the panel's views regarding the problem of industrial deafness through work, and whether they thought that workers should be compensated by right.

MR. F. REYNOLDS said he would be guarded in his reply, as he was sure Mr. Haynes would want to comment on compensation for industrial deafness. The prime responsibility for controlling noise-induced deafness in industry rested with the industrialists on whose premises the noise was created, and also in co-operation with the people employed in that plant. The responsibility for enforcement of the Health and Safety at Work Act in those types of industry which normally produced high noise levels lay with the Health and Safety Executive, not the local authority. The local authority had no responsibility in the vast majority of industrial situations where noise-induced deafness could arise. The Health and Safety at Work Act laid a general duty on the employer to ensure that he did not in any way damage the health of his employee. It also laid a duty on the employee to make sure that he complied with the directions of the employer in respect of himself and his colleagues working alongside him.

Generally, most competent employers now had, where there was a need for it, a noise conservation programme. And, as part of that programme, they would do their utmost to attempt to identify noisy situations where noise-induced deafness could arise. They would then normally attempt either to relocate noisy plant within acoustic booths or locate the operator himself in an insulated compartment away from the noisy unit; or they would provide ear defenders of one type or another.

The actual level which had to be avoided over a period of time and which was likely to cause noise-induced deafness

was 90 dB(A), based on the Leq scale over a 40-hour week over a 40-year life. As long as the noise received by the employee was less than that over any period of time, then it was unlikely that there would be a significant amount of noise-induced deafness. The Americans had a higher standard: a lower figure of 85 dB(A) was prescribed and that figure was also being considered in the UK.

Compensation was really a question of the application of Common Law, if necessary involving proof of negligence on the part of the industrialist or the worker. He tended to agree that there could be more opportunity for compensation, whether State compensation or compensation from the employer in the event that someone had suffered noise-induced hearing loss. There had been a fair number of cases but they had gone in both directions when they had been taken to the Courts; some for the affected person, usually taken by the Union, and some for the employer.

MR. F. HAYNES, MP, said that the other thing in relation to noise-induced hearing loss was the question of State disablement. With accidents in industry (outside of hearing) the one usually went with the other if the employer's negligence had been proven. There were usually two distinct settlements. He had served on the Working Party within the House, along with Jack Ashley, on the question of State benefits for industrial hearing loss. However, a lot needed to be done in other areas also.

He believed that the deaf adults of tomorrow were being created in discos. He, for example, was sometimes invited to assist in judging a dance competition. The youngsters would go, and their parents would go to watch. So the dance had to cater for the young and the not so young. There would be a 3-piece band and a group, but when the group started to play, he found he had to walk out of the place. It seemed to him that not enough was being done about noise levels in such places. It was right and fair enough to be in industry and keeping management on their toes, keeping the trade unionist and the worker on his toes, to use the equipment provided for his protection. However, when it came to the question of entertainment and leisure hours,

people subjected their hearing voluntarily to that sort of noise.

MR. F. REYNOLDS said that fortunately or unfortunately, the problem of potential hearing loss in discos had first raised its head in Leeds in about 1972, as a result of some work carried out by Ron Fearn of Leeds Polytechnic. That had resulted in quite a lot of effort being exerted by the then Leeds Anti-Pollution Sub-Committee and the Licensing Sub-Committee who put conditions on licences for certain types of entertainment in Leeds. Initially, the noise level recommended for the licence had been 90 dB(A) peak. That had been later modified to enable the 90 dB(A) limit to be exceeded for 10% of the time. It had been modified again later as a result of pressures from the entertainment industry to 96 dB(A).

There had been a lot of research on the subject and the latest piece of information published was by John Bickerdyke of Leeds Polytechnic who had undertaken quite an extensive study for the Noise Advisory Council's Hazards to Hearing Working Party. That had been published some 3 months previously; it was available from Leeds Polytechnic if anybody wanted it and there was a further piece of research which hopefully was to be published in the next few months - again by Ron Fearn who had done some work for the Medical Research Council. He was not ready to publish his thesis yet; but it was hoped that it would agree with John Bickerdyke's work. Essentially, what John Bickerdyke had said was that providing the internal acoustic environment was reasonable around the room, that no individuals were too close to individual speakers and so on, the overall internal environment could be about 96 dB(A) Leq. That was well above the 90 level but hopefully the youngsters who attended discos were not also being affected for a 40-hour week by industrial noise levels that were above 90 dB(A). He anticipated that local authorities would renew their interest in the subject when Fearn's work was published.

MR. E. FULLER (Rotherham Borough Council) referring to Mr. Reynolds' comments said that Rotherham had a Noise Abatement Zone. It covered a trading estate with 53 industrial

or warehousing premises. The officers had started monitoring and the monitoring team should, by that time, have completed more than 10 premises. It was a perfect estate for a noise abatement zone. He agreed with the point about the engineering exercise in locating trouble spots but he said that it was not possible to know how effective efforts had been unless monitoring had been done, initially, since the ear was not sensitive enough to detect day to day variations. He did not think that that particular noise abatement zone would produce any startling developments. It adjoined two general improvement areas of probably 1000 houses altogether and the Council were really looking at it from the point of insurance against noise in 5 or 10 years' time.

MR. H. R. VAUGHAN (Westminster City Council) said that he had been rather distressed, during the course of the Conference, to hear some of the delegates from local authorities wringing their hands and bemoaning their lack of power. He thought, therefore, that it was timely to remind delegates from local authorities about a certain piece of legislation which conferred extensive powers on local authorities, which seemed to him to be deserving a wider and more frequent use in relation to pollution control. That little gem of legislation was Section 222 of the Local Government Act of 1972. Listening to the remarks of some of the earlier speakers, he wondered if it was as widely known as it ought to be.

He then read out "Section 222. The power of local authorities to prosecute or defend legal proceedings. Where a local authority considers it expedient for a promotion or protection of the interests of the inhabitants of their area, they may prosecute or defend or appear in any legal proceedings and, in the case of civil proceedings, may institute them in their own name". The section enabled local authorities to take proceedings in any Court - not just Magistrates Courts - in cases which would normally fall within the purlieu of the police, aggrieved individuals, the Alkali Inspectorate, or the Department of the Director of Public Prosecutions, and to take such cases without reference to or the permission of Chief Constables, the Department of the Environment or the Director of Public Prosecutions.

He asked the members of the panel whether, in fact, his reading of that section was correct, whether it did confer such wide powers, or whether they had any experience of any limitations on those powers - and whether they had any experience of the use of the section.

MR. P. EVANS said that he had not come across an example of the use of the powers given under Section 222 of the Local Government Act. He had made some enquiries, having read it, as to exactly how limited it might be, and he had not yet come to any conclusion. He had always understood it to mean simply that local authorities were permitted to take legal action. He would have assumed that it was restricted to taking legal action in cases where local authorities did not have specific powers in relation to the matter in hand. He would not have thought, for example, that local authorities could prosecute an action under that section where it would have been more reasonable to take action under Statutory Nuisance Powers. But that was an impression rather than a considered legal opinion. He wondered whether Mr. Vaughan had in mind a particular way that Section 222 could actually cut across some difficulties and allow him to get at some problem that he felt was not adequately covered elsewhere.

MR. M. TUNNICLIFFE said that, similarly to Paul Evans, he did not know of cases concerning emissions to the air but he knew of one instance concerning a registered works where it had been considered by the local authority. He thought that some test cases would be needed before its potential implications could be understood better. So far as he understood it, the Act would allow a local authority itself to institute civil proceedings, which might be relator actions, in other words to take over actions which had been for alleged private nuisance.

MR. F. REYNOLDS said he had no experience of the use of Section 222. He did not know exactly what it meant except that it appeared to have a very wide application. Whether the apparent flexibility was likely to be restricted when a case eventually got it into the higher courts was a matter for speculation. What was far more important in relation to some of the problems that had been discussed was the Section

100 procedure available under Part III of the Public Health Act 1936, which gave the local authority the power to go straight into the High Court instead of dealing with a problem under the normal Nuisance Procedure.

The procedure was quite powerful; it had been used to close down various types of premises where otherwise it would have been impossible to prevent nuisance. The DOE's 1979 Consultative Document on Offensive Trades had even discussed whether or not Section 100 ought to be revoked because it was too powerful. Personally, he did not like that idea at all; in fact there was just a possibility in his own authority right at that time that they would be commencing a Section 100 procedure in his absence. He had given the authority for it the week before and it could actually be proceeding, as he spoke, on a farm odour problem. He hoped that that sort of action could be continued if necessary.

MR. VAUGHAN (Westminster) said that his reason for raising the question - as he had indicated earlier - was that he had been depressed by the extent to which local authority delegates at the conference seemed to be saying they had no powers to deal with quite serious pollution problems. He was thinking in particular of the South Wales affair, where it seemed to him that there was absolutely no reason why the local authority could not go to the High Court for an injunction against the National Coal Board.

COUNCILLOR PHILIP JONES (Leeds City Council) returned to the question of opencast mining which had first been raised during the proceedings of Tuesday. He did not think that the question had been dealt with adequately and he wanted to know whether the demand for abundant, profitable coal would invariably outweigh opposition to local dust and noise problems? He said that Sir Derek Ezra had shown a slide of the agricultural reinstatement of land whilst spoil was being deposited. He asked whether Mr. Haynes had any knowledge of that being future NCB policy. It did not seem to be general practice in South and South West Yorkshire. The normal scenery there was barren spoil heaps that caused further disruption and were subsequently re-contoured and reinstated, sometimes at the cost of the County Council.

MR. F. HAYNES, MP, said that he knew little about Yorkshire as far as that kind of work was concerned. Apparently Sir Derek Ezra had been talking about the Bentinck reclamation scheme. In Nottinghamshire, the Nottinghamshire County Council had always fallen over itself to work with the National Coal Board, not only on the question of reclamation, but on the question of any planned extension of a tip. It had in the past got to the point where the pit, or the management in the NCB, had been talking to the County Council and had said, "If you do not remove your objections, it could mean the pit closing down because of the need for a tipping area". However, the NCB and the Nottinghamshire County Council worked together and Sir Derek had given a classic example of the results that could be achieved. It happened in other placed in the country, not only in Nottinghamshire.

Mr. Haynes said he was a bit surprised to hear a question of that sort from Yorkshire. He had the impression that no matter where the NCB worked, it carried out the same sort of work in each place. He knew that the Coal Board poured a lot of money into land reclamation. So, for that matter, did the County Councils. In Nottinghamshire there had been a number of crops off reclaimed tips as well as grazing for cattle. However, he thought that the National Coal Board had to rethink its policy in relation to the future as far as tipping was concerned because it could not be done endlessly. Another method had to be devised, whereby waste would not be seen on the top; he thought the Coal Board should be undertaking considerable research as far as waste was concerned.

MR. F. REYNOLDS said that his own responsibility was for Leeds and he did not know of any working deep mine in the West Yorks area where tipped spoil was concurrently being returned to agricultural use in the way that the Bentinck spoil heap was being treated. Delegates from the South Yorks area might wish to make some comment on the situation there.

He thought that perhaps Councillor Jones was taking up, in part, his own reference to the NCB, made the previous day, as

a thundering great juggernaut with a human dynamo, Sir Derek Ezra, in the driving seat. While it was not necessarily desirable to stop the juggernaut, at least it should be brought under some sort of control. His own authority's experience in Leeds certainly had not been that the NCB was environmentally responsible or responsive in any way, but that was in relation to opencast mining, not deep mining. He was well aware of the way in which the NCB had had to co-operate with Selby DC and the North Yorkshire County Council on the Selby field. He thought that the pithead constructions were very good indeed. But with opencast mining, the NCB were nothing more than a thundering great juggernaut and one hell of an organisation to deal with. They started by offering nothing. They attempted to take everything. And, as a local authority, Leeds had one tremendously big fight to gain any ground at all in relation to the conditions which were hopefully attached to the opencast workings when they did go ahead.

MR. P. EVANS thought that part of Councillor Jones' question had been really who was going to strike the right balance between the profitability of the opencast site and the problems that occurred. The Commission on Energy and the Environment were looking very closely indeed at that question, and they had been taken round some areas in Yorkshire and Durham where reclamation work had been going on to see what immediate and long-term environmental impact there was from opencast workings in assessing the consequences of possible raising of future demand for coal.

MR. W. B. TWYFORD (Yorkshire and Humberside Division, NSCA) said that he was not specifically speaking for Wakefield City. There had been problems in Wakefield with opencast mining undertaking by the NCB. He could certainly confirm the impressions which had been given by Frank Reynolds, that if Councils were prepared to let the NCB ride roughshod over them with opencast work, the NCB would do so. It was essential to stand up to them to fight for what was right. The NCB sought to work on a purely economical base. That involved the use of heavy equipment at hours wich were completely unacceptable to the average residents of the area.

He could speak personally on the subject as he lived very close to an area which had recently been subjected to open-cast mining, and which was currently in the process of re-development. The noise nuisance both from the equipment and transport used in connection with opencast and the reclamation of the site could cause considerable disturbance. Wakefield had, as an Authority, done a great deal of work on that. They felt that their experience was probably second to none.

It was his hope that in February of 1981, the Yorkshire and Humberside Division of the NSCA would hold a meeting, which would probably be an open meeting, when the subject of open-cast workings would be discussed in detail together with a display of the equipment which Wakefield had found it necessary to buy in order to monitor the disturbance to the environment. He said that if members from any other Divisions of the Society wanted to receive notice of the meeting, they should contact him and he would be pleased to forward information to them as soon as the arrangements were finalised.

MR. F. REYNOLDS, adding to Mr. Twyford's comments, said that opencasting did not create only a noise problem; the noise problem was secondary as far as his local authority were concerned in Leeds. The dust created as a result of stripping the overburden from the site was quite enormous, and if that coincided with a windy period, as it had done about three weeks previously, then the rate of deposition on people's houses and in people's homes could be really enormous.

As an example, his department had received a complaint, from one of their regular complainants who lived very close to one of the sites, that, following a wind of about two days' duration, the whole of his house and the interior of his house had been covered in dry, grey deposit. His department had taken samples, which had been weighed; the calculation, carried out on the basis of the rate of deposition, had been that 4.09 grams per metre squared had been deposited in approximately seven days (since the complainant had last dusted the particular area - it could have been in two days). That was equivalent in that seven-day period to 10.4 tons

per square mile, which was a very heavy rate of deposition of windborne dust from the overburden as part of an opencast situation.

No one would say that it was necessarily possible totally to avoid such pollution. On a dry windy day, no amount of water spray would prevent that dust rising. But the point was that the NCB simply would not accept any responsibility for it at all. They would not help the complainants in terms of window cleaning; they would not help them in terms of the general house-painting, they accepted no responsibility for it whatever. All they would say was "Well you have got a problem. Apply for a rating reduction and see what happens then". That was the sort of response typical of the Open Cast Executive.

COUNCILLOR H. DALEY said that he took umbrage at speakers lining up to criticise the Coal Board when there had been a golden opportunity, when the Chairman of the Coal Board had been present at Conference on the Tuesday, to take such questions. He had noted that when there had been five energy spokesmen on the platform, people had been taking the opportunity to ask questions about mining subsidence and the fracturing of sewers etc. instead of the sorts of questions which were now being raised.

Someone had said that morning that the name of the Society should be changed to the Clean Air Society plus the Environment; Councillor Daley said that there was a danger of the Society taking over the responsibilities of the Planning departments. If Mr. Reynolds or Mr. Twyford or anybody else was not satisfied with the conditions that were put down on opencast mining they should have a word with their colleagues inside the Planning Department who laid down the conditions and were responsible for enforcing the hours of work, etc.

The discussion might just as easily be about the noise from the Yorkshire copperworks or the shunting sheds. He was not defending opencast mining, because he was himself a deep coal miner, but he thought it cowardly to attack the Coal Board when Coal Board Members were not present to defend themselves. The Coal Board was the only employer in the

land, as far as he knew, which was still taking men on the books, and boys from school, while everybody else was laying men off; it was doing that because, as Sir Derek Ezra had explained earlier, although the winds were blowing fast and loose, the Board were going to continue with their aim for that plan for coal and, to that end, they were not laying men off, they were taking boys on. There was a lot of credit due to them for that.

In Leeds, there was only the one colliery, Rothwell, in the district. The question from the Leeds Councillor had been about restoration after opencast mining. He asked to be told where, in Leeds or Wakefield, land was not being restored after opencast mining and put back to either agricultural use or for potential leisure areas. It was happening now in the Wakefield Metropolitan area. It had not happened in the past but it was happening now and he thought it was time that people stopped aiming at one of the main employers in the area.

MR. F. REYNOLDS said that he had been at the Energy session, but unfortunately so much time had been taken up by problems with subsidence, that he had not been able to reach the rostrum!

MR. W. B. TWYFORD said that the Chairman had put him in a very embarrassing position, as Councillor Daley was Deputy Chairman of his authority of Wakefield. For that reason, Mr. Twyford had emphasised that he had been speaking as the representative of the Yorkshire & Humberside Division, NSCA. He was not knocking the NCB, and, as he had been engaged on Society business, he had missed Sir Derek Ezra's speech on the Tuesday.

He did not dispute a word that Councillor Daley had said about the aims of the NCB. The NCB set out to produce coal economically. The point he had been making, in support of the point made by Frank Reynolds, was that unless local authorities stood up to the NCB, the NCB would certainly try to ride roughshod over a local authority. If a local authority stood up to the NCB, they could get good terms from them. It was felt in Wakefield that they had done this.

But they had, to some extent, been guinea pigs, and there were parts of Wakefield Metropolitan district which had had a fairly rough ride during the previous few years. With the experience that they had gained during that period, they could ensure that other areas did not similarly suffer. It was that experience and that information and expertise that they were proposing to make available to members of the Society at the Divisional Meeting which would hopefully be held in Wakefield in February 1981. It was not a case of knocking the NCB; it was a case of supporting a colleague. The NCB needed to be met just as firmly as their approach was made.

MR. F. REYNOLDS did not think that there was much that he could add to Mr. Twyford's remarks. However, he was a little surprised by Councillor Daley's comments, in view of the trouble that Wakefield had had. Councillor Daley would also know that the District Council's responsibility was very limited when it came to opencast working, except to deal with nuisances as and when they arose.

Mr. Reynolds explained that his own department advised the district planners and were also in liaison with the county planners. It was the county planners who had the prime responsibility when it came to developments and minerals' reclamation, but in any event, neither could give planning permission because what was required was an Authorisation granted by the Department of Energy.

Ultimately the responsibility went right back to a central government department, and all the local authority could do was to make quite certain that at least they obtained reasonable conditions, agreed conditions, from the NCB before the application for authorisation was sent to the Department of Energy who would then consider it. He repeated that it was damned hard work to get anything else from the Board. If they would at least come forward, explain what they had done for other areas and say that they were prepared to do not less than that, it would be an improvement. At least it would be a starting point; but instead local authorities always had to work from the bottom and creep right up.

MR. A. J. CLARKE (Chairman) asked, as a supplementary to the last question, whether the Alkali Inspectorate had any responsibility for dust emissions produced during the mining of coal, whether surface or deep mine.

MR. TUNNICLIFFE said that it was not a registrable process. Some coal processing plants were registrable and then of course dust, as part of that operation, was controlled, but opencast mining itself was not registrable.

MR. K. TEESDALE (Ford Motor Company) said that his was a rather brutal question in a way but it linked three things that three speakers had already brought up. Mr. O'Brian had talked during the previous session about the possible re-titling of the Society, in view of the fact that it was now putting a lot of stress on noise (which had certainly been evident at the Conference). Mr. Clarke had spoken about the future of the Society and its aims and balance, and of the discussions currently taking place. Mr. Archer had during the discussion on the Society's "Pollution from Road Vehicles" booklet, drawn attention to the aspect of toxic and hazardous substances and health and safety at work. If those three things could be taken together, he wanted to ask a broad question of Mr. Clarke and possibly Mr. Tunnicliffe.

Looking at environmental pollution and clean air matters, there had been great successes, while it was still necessary to be vigilant. The Society was beginning to put a lot of stress on noise, but it was possible to break the legislation in all sorts of other ways; the asbestos problem raised by Mr. Archer was typical of the new octupus of concerns. He asked to what extent Mr. Clarke felt that the Society might include those other types of pollutants within its remit, and to what extent Mr. Tunnicliffe felt that they were, from his side, becoming important. He was really talking about the whole band of toxic and hazardous substances, and health and safety at work.

MR. TUNNICLIFFE said that it was a very wide question to attempt to deal with in the closing few minutes of the Conference. But it was very clear, not only in the UK but internationally as well, that the whole subject of the

appearance of new chemical substances in the environment, coming principally from industrial activities and therefore also having importance for occupational health, had to some extent replaced in the last few years the more traditional emphases of air pollution control, such as smoke, grit, dust, sulphur dioxide, etc., the category of common pollutants that had been the object of concern to the Society for so many years. Whether that was the beginning of a permanent trend was not yet clear. It was certainly an aspect which the regulatory authorities, bodies such as the Health and Safety Executive had to take account of because of its relationship to occupational exposure, and there was also a European Community interest. Therefore it was a matter of current interest; and it could be a matter of interest to individual local authorities who comprise much of the membership of the Society, so that it might be a debate that the Society could take up.

MR. F. REYNOLDS saw no reason why the Society should not be involved with the problem within its general concern for the environment. However, there was a limited amount of information, if any information at all, on the concentrations of trace pollutants in the general environment. There was a reasonable amount known about them within the context of the working environment; there was a reasonable amount known about them in relation to their toxicity in a working environment and the possible effects on the human system. A fair amount of work had been done on certain heavy metals in the general environment, particularly lead, and their effects, particularly again on the young and the old. But to start in attempting to monitor (a) the concentration of the trace pollutants and then (b) their epidemiology, was one hell of a problem.

He doubted whether the instrumentation was available to measure adequately and accurately the sorts of concentrations that arose in connection with some of the problems in the environment around industry. That was an area for future scientific development of instrumentation as much as anything else initially. But then, when that had been achieved, he doubted whether local authorities would be able to afford to use it.

MR. A. J. CLARKE thanked Mr. Reynolds and said that he had to draw the Session to a close. On the last question asked, which had also been directed to him, he thought a correct but rather devious answer might be that the Society existed to discuss any matters that its members wished to discuss. Mr. Clarke stressed that there was no 'us' and 'them'; the invitation to Divisions referred to that morning had been to communicate on any matter relevant to the future of the Society and on its structure. He urged individuals as well as Divisions to respond and assured delegates that everyone's views would be taken into consideration. He wished to sound a note of warning, however, that the Society depended on the expertise of voluntary members. There was no central professional body within the Society looking at the pollution problems. Before recommending consideration of some of the more esoteric forms of pollution, the question had to be asked whether members having the proper expertise existed within the Society and if not whether we ought to be going out to find them and bring them into the fold. These were matters to be considered in the current review.

Returning to the present session, Mr. Clarke concluded that the questions had covered a great deal of ground; noise in relation to abatement zones and industrial deafness; powers of Local Authorities under the Local Government Act; restoration of spoil heaps; and finally the range of activities of the Society itself.

INDEX TO SPEAKERS